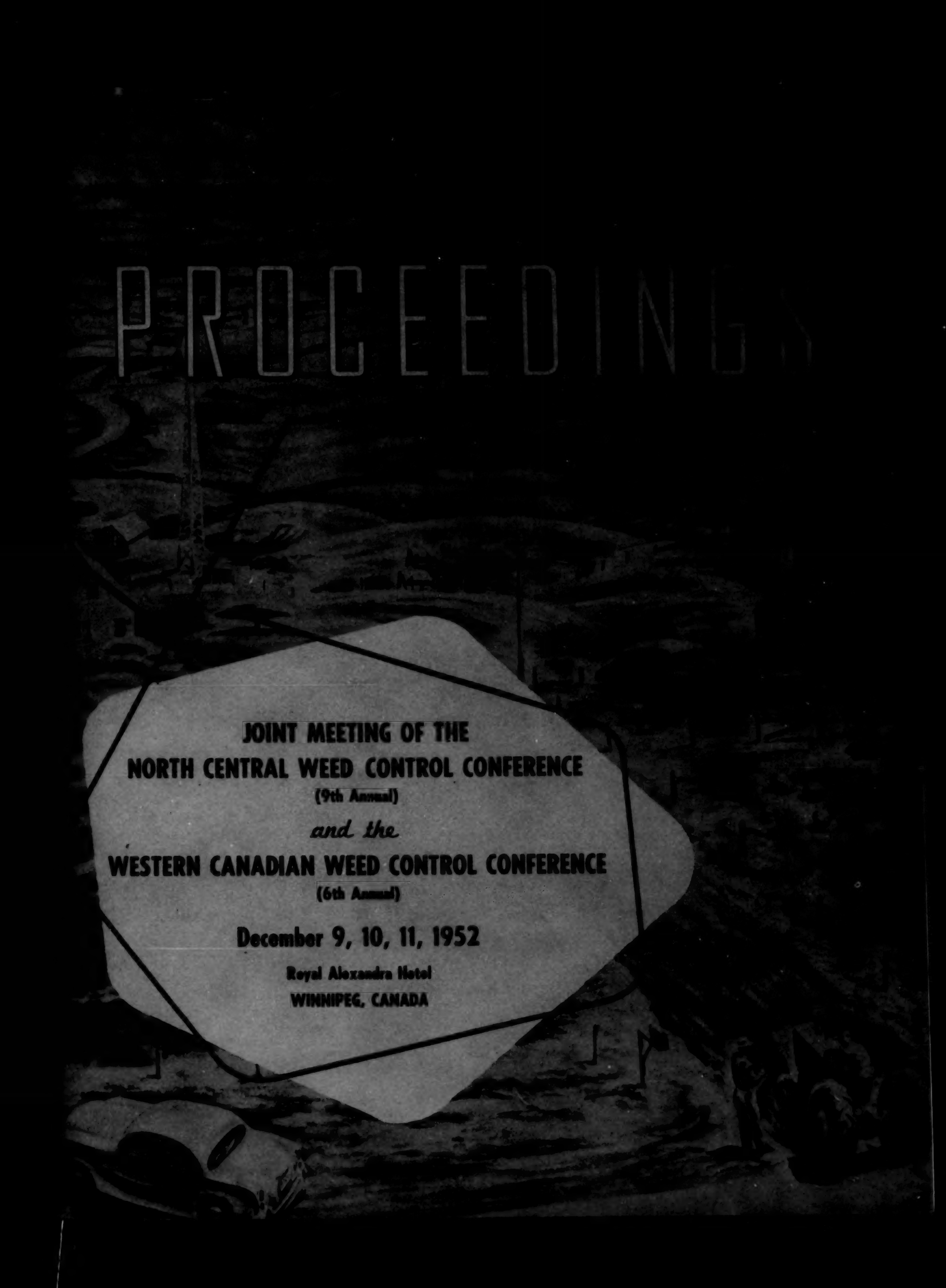
PROCEEDINGS



JOINT MEETING OF THE
NORTH CENTRAL WEED CONTROL CONFERENCE
(9th Annual)

and the

WESTERN CANADIAN WEED CONTROL CONFERENCE
(6th Annual)

December 9, 10, 11, 1952

Royal Alexandra Hotel

WINNIPEG, CANADA

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PREFACE

The Proceedings of the Ninth Annual Meeting of the North Central Weed Control Conference and the Sixth Annual meeting of the Western Canadian Weed Control Conference held jointly at Winnipeg, Manitoba, Canada, December 9, 10, 11, 1952, are a record of the formal papers and reports of the committees of the Conferences. All questions from the floor, introductions and other discussions are omitted.

Additional copies of the 1952 Proceedings are available at $2.00 per copy from F.W. Slife, College of Agriculture, University of Illinois, Urbana, Illinois, or from H.E. Wood, Publications Branch, Dept. of Agriculture, Legislative Building, Winnipeg, Canada.(Canadians please order from Winnipeg).

PROGRAM AND TABLE OF CONTENTS

Tuesday Morning, December 9, 1952

General Session: Chairman: H.E. Wood

Film -
"Enough and For All," Courtesy, Massey-Harris Co. Ltd.
Official Opening -
Hon. R.D. Robertson, Minister of Agriculture and Immigration, Manitoba..

President's Address -
K.P. Buchholtz. 1
Effects of Herbicides on Cereals with Special Reference to Oats -
P.J. Olson 2
Effects of Herbicides on Flax -
R.S. Dunham 4
New Aspects of Weed Control on Flax -
Wm. H. Silversides 5
Physiological Aspects of Micro-Nutrient Sprays and Dusts -
D.J. Wort 6
2,4-D With Additives of Leaf-Feeding Properties -
P.O. Ripley 8
New Aspects of Weed Control on Flax in the United States -
W.P. MacDonald 11

Tuesday Afternoon, December 9, 1952

General Session: Chairman: N.H. Putnam

Dominion-Provincial Weed Surveys -
R.T. Coupland 12
Panel Discussion - "Persistent Perennial Weeds"
The Problem in the Prairie Provinces -
T.V. Beck 14
Chemical Control -
W.G. Corns 15
Cultural and Other Control Methods -
H.A. Craig 17

Weed Screenings and Their Disposal -
H.J. Mather 18
Panel Discussion - "The Wild Oat"
Occurrence in Joint Conference Area -
H.E. Wood 20
Taxonomic Investigation -
D.R. Lindsay 20
Cultural Control -
D.A. Brown 22
Chemical Control -
H.W. Leggett 23
Control Methods Followed in the United States -
E.A. Helgeson 25

Tuesday Evening, December 9, 1952

Basic Studies Section: Chairman: W.E. Loomis

THEME - "Botany and Physiology of Weed Control".
Absorption and Translocation of 2,4-D -
E.W. Hauser and D.W. Young 27
Translocation of Herbicides in Leafy Spurge -
C.M. Switzer and R.O. Bibbey 32
Effects of 2,4-D on Plant Enzyme Systems -
D.J. Wort 32
Life-history Studies of Weed Species -
R.T. Coupland 35
Effects of Maleic Hydrazide on Respiration of Roots -
Saul Zalik 36

Wednesday Morning, December 10, 1952

General Session: Chairman: L.M. Stahler

Film - "Prairie Conquest" - Courtesy, National Grain Co. Ltd.
Panel Discussion - "Trends in Applications of Herbicides"
Comparisons of Present Methods of Application -
J.R. Foster 36
General Developments of Boomless Sprayers -
G.L. Shanks 38
Recent Experimental Work with Broad-Jet Nozzles -
C.S. Corl 40

Aerial Application Techniques -
Russell Larsen 41
Factors Affecting the Distribution of Spray From Airplanes -
J.C. Chamberlin 42
Railway Application Equipment -
Hillard L. Smith 43

Wednesday Afternoon, December 10, 1952.

Sectional Meetings:

Section 1. Industry — Chairman: Keith Barrons

Strengthening Industry-Government Cooperation Through the NCWCC -
K.P. Buchholtz 45
Complying with Government Regulations in Merchandising Herbicides:
Canada - P.M. Overholt 46
United States - J.A. Noone 47
Control of Vegetation Along Roadbeds and Similar Areas -
D.W. Young 47
The Role of the Farm Press in Promoting Better Weed Control -
Wallace D. Inman 50
Panel Discussion: "Where Are We Headed with Aerial Application"
- John Burke, Panel Chairman, will introduce participating members 50
Business Session of the Industry Section of the NCWCC

Section 11. Brush Control — Chairman: E.P. Sylwester

Observations on the Rate and Nature of Brush Invasion -
H.L. Hanson 51
Brush Control of Hardwoods for Grass Production -
Harry M. Elwell 53
Brush Control in the Future -
R.H. Beatty 57
Recent Research in Chemical Brush Control -
J.W. Suggitt 59

Chairman: Hillard L. Smith

Dormant Spraying of Woody Growth with Buffalo Turbine -
L. Playfair 63
Brush Control on Right-of-Ways by Basal Stem and Trunk Treatment -
Elvin Durr 64
Service Organizations Part in a Planned Brush Control Program -
Charles O. Laverty 65
What Can a Utility Company Expect from a Planned Chemical Brush Control Program? -
T.J. Sullivan 67

Section 111. Horticulture — Chairman: L.G. Holm

Chemical Weed Control in Canning Peas -
J.C.M. L'Arrivee 68
The Effect of Weed Competition on the Growth and Development of Carrots -
C.A. Shadbolt and L.G. Holm 69
Pre-Emergence Chemical Weed Control in Beets, Spinach, and Certain Crucifers -
E.K. Alban (no paper)
CMU as an Herbicide for Vegetable Crops -
D.D. Hemphill 70
The Control of Weeds in Onions with Pre-Emergence Sprays -
R.E. Nylund 71
Herbicidal Mixtures for Weed Control in Vegetable Crops -
G.F. Warren and J.E. Larson 72
Control of Wild Oats and Volunteer Grain in Sugar Beets with IPC -
R.T. Nelson 73
The Control of Weeds in Canning Peas with MCP -
K.P. Buchholtz 75
Physiological Studies on the Behavior of TCA in Vegetable Crops and Soils -
T.W. Tibbitts and L.G. Holm 76
Chemical Weed Control in Sugar Beets -
E. T. Anderson and J. C. M. L'Arrivee 77
Pre-and-Post Emergence Weed Control in Onions -
E.K. Alban 77

Section 1V Extension and Regulatory

Extension: — Chairman: Ralph Crim

Ways and Means of Getting Information on Weeds and their Control to the Farmers -
A.F. Shaw 81
Our County Weed Control Program, Organization and Accomplishments -
A.B. Hagen 82

Regulatory: Chairman: Sig. Bjerken

The Application of Canadian Weed Control Legislation -
G.R. Sterling 82
Coordination of Regulatory, Extension, Research, and Industry in Weed Control -
T.L. Aamodt (no paper)
Coordination of the Work Between Regulatory People of the States and Provinces of Canada -
Crawford Winton 85
Weed Control on Railroad Right-of-Ways -
S.J. Oberhauser 86
Pending Weed Legislation -
Charles Gilbert 87

Wednesday Evening, December 10, 1952

Chairman: Dr. F.J. Greaney

Banquet -
Main Dining Room, Royal Alexandra Hotel
Guest Speaker - Mr. Justice Freedman 88
"Canada - An American Nation in the Commonwealth".
Awards 88

Thursday Morning, December 11, 1952

General Session: Chairman: C.J. Willard

Some New Weed Problems -
A.H. Larson 88
Control of Weed Hazards to Health -
B.H. Grigsby 90
Desiccants and Pre-Harvest Treatments -
Fred Slife 91
A Balanced Weed Control Program -
Lyle A. Derscheid 93
Question Box - Panel of Specialists from the Region.

Thursday Afternoon, December 11, 1952

General Session: Chairman: K.P. Buchholtz

Problems in Registration of Herbicides -
J.A. Noone 95
Panel Discussion -
"Present Status of New Chemicals " Chairman: W.C. Dutton
Isopropyl-N-(3-chlorophenyl) carbamate (CIPC) -
R.S. Dunham 98
Ethyl trichlorobenzoate, Methyl trichlorobenzoate and Octachlorocylohexanone -
E.K. Alban 98
Sodium, 2,4-dichlorophenoxyethyl sulfate (SES) and Sodium 2,4-dichlorophenoxyethyl benzoate (Sesin) -
D.D. Hemphill 99
Maleic hydrazide (MH) -
L.G. Holm 99
N-1-naphthyl phthalamic acid -
G.F. Warren 100
3-p-chlorophenyl-1-1-dimethylurea (CMU)
C.J. Willard 101
Other new chemicals -
W.C. Dutton 102

Committee Reports NCWCC
Research Recommendations 103
Terminology Recommendations 111
Resolutions 112
Appended from WCWCC
Use of 2,4-D in Western Canada -
H.E. Wood 113
Herbicide Recommendations 113
Machinery Recommendations 114
Tillage and Cropping Recommendations 115

Registration List 118

Member Commerical Organizations 125

List of Exhibitors. 126

PRESIDENT'S ADDRESS

WEED CONTROL - A KEY TO PRODUCTION

K.P. Buchholtz, University of Wisconsin

For some time I have looked forward to welcoming you to this joint meeting of the North Central and Western Canadian Weed Control Conferences. Those of us from the States feel privileged to meet so many interested in weed control work from the Canadian provinces. We know them to be a group of energetic, thorough and progressive workers who have done much to advance the use of newer weed control methods in their country and in ours as well. During past years their representatives have traveled considerable distances, without complaint, to attend meetings helds in the States. It is entirely fitting, therefore, that this meeting be held in Winnipeg and that we have the opportunity to meet more members of the Canadian group.

My position here should rightly be occupied by Henry Wood. He is chairman of the Western Canadian Weed Control Conference. In addition he has been Chairman of the Joint Conference Committee on General Arrangements. All who have followed the activities leading up to this Joint Conference will agree that Henry Wood has been the kingpin of the organization. His foresight, his judgment and his attention to detail have all contributed immensely to the success of the conference and I do not want them to go unnoted.

During the past few years it has been customary to have the President of the North Central Conference address the group at its first general session each year. Apparently this should be a "State of the Conference" message to determine from where we have come and what our destination may be in the years ahead. Most of you know our history for it is as yet a short one. It is more difficult to determine what the future has in store.

L.W. Kephart once said that the North Central Weed Control Conference had its origin in the mind of the late Ted Yost while standing in the middle of a muddy field in Kansas sometime in October, 1942. If so, this makes our conference ten years of age this year even though this is but our ninth meeting. No one can deny that much progress has been made in the ten years that have elapsed. Weed control has developed from a curiosity holding the attention of only a score or so of people in the entire country. Today it is taking its place as a distinct division of agricultural science. Hundreds and even thousands of persons are engaged in servicing this young science. They may be engaged in industry, in research, in extension or in regulatory activities but all have three common objectives. One objective is to insure that our basic stocks of soil nutrients, light and water are not wasted on weeds of no value as fodd or feed. The second is to ease man's burden of the stooped back, the hoe and the cultivator. The third objective, decreasing the costs of production, is usually achieved concurrently with the first two.

Economists insist that in 25 years we must feed five persons where now we feed four. This cannot be done by expanding our acreages. We have little more in which to expand. The increased supply of feed and food and fiber required, if we are not to reduce our standard of living, must come largely through increased efficiency of production. Each acre must produce more. Certainly we will not underestimate the value of superior varieties of crops, the wise use of fertilizer and the control of insects and diseases in this task. As a group land as individuals, however, we should be especially aware of the possibilities presented by control of weeds in our crop lands.

In past years agricultural workers, of which we are a part, have tended to maintain a defeatist attitude when weeds were considered. We have advised controlling weeds without being very specific or very practical. Having thus discharged our duty, as we saw it, we were content to accept the inevitable. The inevitable has been the consistent losses due to weeds experienced every year and the apparent increase year by year in the numbers and species of weeds with which we are forced to work and live. In the past decade, however, we have had the privilege of witnessing the start of a new era in crop production. The inevitable does not seem as sure now as once it did. New ideas are abroad and old problems are being solved.

Every comprehensive survey of which I am familiar has shown that losses due to weeds exceed those due to any other agricultural pest. It would be unwise to hazard a guess on the proportion of our agricultural resources that weeds squandor but we know that in the aggregate the figure is large. Progress is encouraging, however, and substantial gains have already been made. Estimates by Stahler indicate that in 1949 8 million acres of grain were treated with 2,4-D for weed control in the Prairie Provinces. In 1950 this figure rose to 14 million acres or approximately 50 percent of the wheat acreage in the area. If we assume that yields were increased 20 percent or about 3 bushels per acre by this treatment it must have resulted in an increased yield of 42 million bushels of grain, chiefly wheat. Costs of the chemical and its application have been moderate, averaging from $1.00 to $1.50 per acre. The returns have repaid the investment manyfold.

It is the opinion of many that throughout the United States and Canada weeds cause average annual losses of about 10 percent in our grain yields. If this loss were entirely corrected for our wheat crop alone it would mean the apparent addition of 6.0 million acres of land to the wheat growing area of the United States and 2.5 million acres to Canada. New land frontiers have largely disappeared in our two countries. The new frontiers of achievement in agriculture remain before us awaiting the adventurous spirit and the hardy pioneer as before. In our wheat growing areas we have a frontier of 8.5 million acres that is being added to our farm lands. Much of it is in our most productive farming regions and may be our best land. As pioneers we should not rest until we have claimed it all, for I am certain we have the key to its solution.

Let us consider another example. Ahlgren et al. showed in Wisconsin that for production of forage one acre of cleared land was equal to 5 acres of woodland pasture. Forestry experts have long pointed out that woodland pastures have little or no value for timber. In the 20 northern and eastern states there are about 24 million acres of such mis-used and neglected land. If only one out of every 5 acres was cleared and managed correctly our forage production would be maintained. In addition the remaining four acres would eventually yield an important source of timber to bolster our depleted supplies. If the demand for pasture and forage were to increase, as we suspect it will, we could clear two acres of the five and thereby double our production. Even then our ultimate production of timber on the remaining 3 acres would be infinitely more than we now obtain from all five.

You may wonder why this problem should be the concern of weed workers. The reason of course is because weed workers hold the key to its solution. Hand grubbing has been too slow and in the and too expensive to be helpful in clearing our pastures. The persistent regrowth that results has discouraged all but the most hardy farmers. Use of mechanical tools is not entirely practical because of the high initial investment and the difficulty experienced when working rough, stony land. The use of herbicides, however, has shown great promise in returning these mis-managed lands to their most efficient uses. More study and research is necessary before we can be satisfied with the results but surely we will not fail a problem of this magnitude.

The needs of the producer of vegetables and fruits should also be considered. As our populations increase there will be a greater demand for these products and acreages are certain to increase. These crops do not lend themselves to mechanized production as readily as do field crops. Consequently they have required considerable amounts of hand labor for culture and handling and costs have been high. A substantial portion of this cost has been due to hand weeding. Moreover, it is tedious work that no one finds attractive. The result has been steadily rising costs and increasing difficulty in getting the job done at any price. Producers of onions may at times spend $100 or more per acre to weed their fields. This may represent from 25 to 30 percent of their total production costs. If they do not this expenditure there is likely to be no marketable crop. A reduction in the costs required for weeding would put these speciality crops on a much more stable basis. The vagaries of the weather as it influences the growth of weeds would not then mean the success or failure of a year's planting. The savings accrued would in large measure pass on to the consumer. In addition, use of other than hand methods would free man from a painful, unpleasant job. Agriculture is rapidly becoming mechanized and more efficient operations are the order of the day. Vegetable and fruit production must also strive for these objectives. The possibilities are fully as great and perhaps greater than in field crops.

It is clear that the contributions of the weed workers to our agricultural enterprise have been substantial, and we can expect even greater progress in the future. As we achieve our objectives we will be able to produce more, with less, easier.

These objectives will not be won rapidly nor will they be attained automatically. We must labor and observe and study and promote along the way. Within the past decade we have witnessed the general acceptance of a new technic in weed control. The use of selective herbicides, chiefly 2,4-D, is becoming an accepted practice on millions of acres in the plains states and prairie provinces. We can expect the use of other selective herbicides to increase year by year. Already 2,4,5-T, MCP, TCA and others have found definite niches in our program. As more information is accumulated we can expect this list to be lengthened. In the process we will tend to develop more specialized applications. This may be distressing to some but it appears to be inevitable. We cannot expect an herbicide to control all weeds in all crops. Instead we will approach the opposite pole of an herbicide controlling but one weed in one crop. If such an herbicide were to control quackgrass in corn we would judge it a very worthwhile addition to our list in Wisconsin.

Nor can we confine ourselves to work with herbicides. No one can ever be positive that the important advances in weed control of the future do not lie in the realm of biological controls, better knowledge of seed dormancy mechanisms, or the responses of plants to light, water, temperature and atmospheric and soil gases. The research worker should be aware that the most valued and promising ideas are often found in poorly studied corners and make his plans accordingly.

The proper utilization of the array of herbicides we are likely to have in the future is largely in the hands of our educational leaders. Extension workers in particular must continue to keep abreast of research findings. They must be able to demonstrate and sell the desirability of the new techniques. Research findings, nicely bound and filed, are of little value unless they can be related to problems at hand and incorporated into our common usage. Extension workers are equipped for this integration and can bring it about more effectively than any other group. On their success in the end will depend the value of our entire research program.

Essential too, are the industrial workers. Their effort in making available supplies must not be underestimated. Without industry the advances of the past ten years in weed control would be very modest. If industry had not seized the opportunity presented our lists of herbicides available for use would be much smaller than they are. If industry had not entered into mass production techniques the costs of the materials we use so freely would certainly be higher and their use probably would not be practical on the wide scale desired.

As the fourth member of our team the regulatory worker serves to guide our actions and maintains our objectives in clear perspective. He stands as the first line of defense against the introduction and spread of new weeds. We should all wish him complete success in this undertaking and lend him our support. The lists of noxious weeds in the various states serve to guide the thinking of all others in the field for they have resulted from attempts to evaluate the species most likely to be dangerous and the most deserving of control and study. The regulatory statutes themselves serve as an additional technique for use in our unending task of controlling these important pests.

Finally it is my hope, and that of the other officers, that you will obtain and exchange ideas and experiences of value at this meeting. We hope that you will return to your locality better able to deal with the problems causing you concern. If you find this to be true our efforts will be rewarded and the Conference will have served its purpose successfully. If it does not come true the responsibility is ours alone for I believe the need for and potential value of a Conference such as this is self evident.

EFFECTS OF HERBICIDES ON CEREALS WITH SPECIAL REFERENCE TO OATS

P.J. Olson, University of Manitoba.

The crops involved in this report are barley, wheat and oats.

With reference to barley and wheat, most of the reports of research and experimentation that have appeared recently are confirmatory of what has been fairly well established as regards the reaction of these crops to 2,4-D. What is said here about these is mainly to point up the difference between them and oats, the facts about which have not been so well established.

Some new information about the reaction of these crops to chemicals other than 2,4-D is coming forward.

Barley becomes susceptible to damage from 2,4-D as soon as it emerges. The external manifestations of damage from treatment applied at this

time are the familiar tubular leaves. If the plants produced only a single stem, that is, produced no tillers, this type of damage would continue from treatment applied during a period of 4 or 5 days after emergence. Usually it is the 6th or 7th leaves that show this damage. These leaves are in the process of formation in the still invisible growing point during this time. Severe yield reduction takes place as a result of this type of damage. The spikes have difficulty in emerging from these tubular leaves and usually are highly sterile. Treatment applied from this time to the 3-leaf stage causes spike abnormalities. Clubbed spikes, elongated spike internodes with clustered spikelets, branched spikes, etc., are the common types of abnormalities. While some yield reduction is associated with this type of abnormality it is not severe. During this period the spike is beginning to form its various parts within the tiny growing point hidden away at the base of the plant.

After this period, that is when the main stem is out of the three leaf stage, it is resistant until it is well into the boot stage. From approximately 12 or 14 days before heading up to heading, barley is again highly susceptible. During that time the actual flower parts, that is the stamens, pistil, anthers, pollen, etc., are forming and fertilization is taking place.

In wheat the picture is the same with minor variations which need not be labored here.

As has been pointed out the above description of susceptible and resistant stages applies if the barley plants have only one stem or culm. In most cases barley does tiller more or less so that actually the various periods are somewhat delayed because the tillers develop after the main culms, and they will therefore be in the corresponding susceptible and resistant periods somewhat later than the main culms.

In any case the problem of treatment for the control of weeds in barley and wheat is clear cut and simple. The treatment may be applied at any time after the crop reaches a height of about 5 or 6 inches, that is about two weeks after emergence, until it reaches the shotblade or early boot stage, about one month after emergence. Treatment during the early part of this period is usually ideal. The plants are still young, and will not be unduly damaged by wheels of the equipment. Weed competition will be removed early.

In oats the situation is much less simple. This crop, for practical purposes, is more or less susceptible over the entire period from emergence to late boot stage. Rates of ester down to 6 oz. acid equivalent per acre, or even 4 oz. in some cases, may reduce yields moderately to severely when applied at any time during this period with the exception of occasional gaps of short duration. Actually there is a short period within this longer period during which the crop is particularly susceptible. This comes into expression under moderate dosages or under conditions that are more favorable for escape of damage. This is well illustrated by 3 typical cases. These are tests conducted at Scott, Sask., Brandon, Manitoba and Winnipeg, Manitoba in 1952. In these tests treatments were applied at 3 day intervals starting at or just before emergence and continuing until well past heading. Where 8 oz. ester were applied significant yield reduction took place as a result of every treatment from the 2nd, to the 18th. At Scott the same situation applied from the 2nd to 11th treatments, the latter applied in the boot stage. Where 8 oz. of amine were applied at the same periods there was no significant yield reduction at Scott except from the 6th, 7th, 8th and 9th treatments, with the greatest reduction from the 7th treatment. At Brandon the 8th, 9th and 10th amine treatments caused highly significant yield reduction. The first and 2nd and also the 17th also caused yield depression there, but there was none for the stages in between. Here the 9th treatment caused the greatest yield reduction. At Winnipeg, where conditions this year were evidently more favorable for escape of damage and where 6 oz. of ester instead of 8 were applied the lowest yields were recorded from the 6th and 7th treatments. It seems evident therefore that the oat crop is particularly susceptible at stages starting about jointing, or about the 6-leaf stage, and continuing until just short of the shot blade or early boot stage.

Why this difference between oats on the one hand, and barley and wheat on the other? In the first place oats appear to be more susceptible than barley or wheat. Why is the oat crop particularly susceptible at the stages just pointed out, stages which as far as external development is conerned correspond to a period when barley and wheat are resistant? To begin with the chief manifestation at these stages is sterility. Another manifestation is severe lodging. The reduced yields are probably the result of a combination of both. In these oat experiments reduced yields have generally been associated with the severe lodging that has been induced by treatment. The high degree of sterility appears due to the fact that development of floral parts begin at about this time. Detailed greenhouse studies have shown that the initials of the floral parts, stamens, pistil, anthers, stigma, etc., appear sooner after the differentiation of the inflorescence, in oats than in barley. In barley differentiation of the spike in the main culm or stem began about 8 days after emergence of the crop and was completed about 13 days after emergence. The differentiation of the floral parts - that is anthers, etc., did not begin until 13 or 14 days later. Therefore, there was a period of about 2 weeks when no new organs were forming, and the main culm was therefore, resistant. In oats, on the other hand, differentiation of the panicle did not begin until about 23 days after emergence of the crop. Reduced spikelet number and sterility began in greenhouse plants soon after this time.

In barley the production of leaf initials and consequent production of tubular leaves when treatment was applied during such production, continued for only 4 or 5 days. In oats the corresponding period continued 14 or 15 days. This is a period of severe yield reduction, because of the difficulty or failure of panicles to emerge later on, as already pointed out. Taking into account tiller development this means that this type of seedling susceptibility is spread over a long period of time. In our greenhouse studies leaf abnormalities in oats continued over a period of 26 days, while in barley they covered a period of only 10 days.

What do we do as regards treatment of oats?

Obviously the periods of actual resistance in oats, as far as heavy doses of 2,4-D are concerned, at best are short. It has been suggested that treatment may be applied with reasonable safety just before or in the very early shot blade or boot stage. But this is not a practical procedure, since weeds will already have effected a good deal of competition, and considerable damage to the crop may be done where ground equipment is used.

On the optimistic side it should be pointed out that even moderate dosages often fail to do severe damage, environment being the important factor. As a case in point witness the Winnipeg results already presented. Moreover, tillers well established before, or starting after treatment may bring about almost complete recovery. It would be prudent to dodge the apparently short most susceptible period starting at the jointing or 6-leaf stage, treating during the latter part of the preceding period, in other words at about

the 3 or 4-leaf stage. If one used the amine of 2,4-D, or of MCP, at doses sufficient to destroy the more susceptible weeds, one would seemingly be reasonably safe.

With reference to substitution of MCP for 2, 4-D accumulating evidence indicates that there is some advantage for 2,4-D over corresponding formulations of MCP, although in many cases the advantage is small. Wherever damage to the crop was recorded, MCP showed less than 2,4-D.

EFFECTS OF HERBICIDES ON FLAX

R.S. Dunham, University of Minnesota

Although the title of this paper is very inclusive, I shall restrict my remarks to the effects of 2,4-D, MCP, and TCA on oil flax. In the early days of 2,4-D, it was assumed that flax would be susceptible to this herbicide because it is a dicotyledonous plant. The present use of 2,4-D, MCP, and TCA has been a real boon to farmers and has transformed flax from one of the weediest crops on the farm to potentially one of the cleanest. Actually, flax is less tolerant of 2,4-D than the small grains; If it is kept free of weeds by hand work on experimental plots and is then sprayed with 2,4-D, the yield may be reduced by as little as 2 oz. of the amine or 0.5 oz. of the ester per acre. Fortunately, however, the common weeds of flax are relatively more susceptible to 2, 4-D than the crop and MCP is less injurious than 2, 4-D.

Susceptibility to herbicides may be measured in several ways; by (1) abnormalities induced by the treatment, (2) effect on maturity (3) yield of seed (4) quality, and (5) effect on continuously treated progeny. Susceptibility, as measured by all of these yardsticks, is affected by variety, time of application, and the kind of herbicide. Varietal differences to 2,4-D are considerable and have been reported by Dunham, Tandon, Robinson, Coupland, Davidson, Friesen, Olson, Breakey, and Alex. Time of application is important because flax responds differently when sprayed at various stages of growth and also when under differing environmental conditions.

Flax is more tolerant of MCP than 2,4-D and among the formulations of 2,4-D it is more tolerant of the sodium and amine salts than the esters. Varietal differences are less important when MCP is used instead of 2,4-D and when the salts of 2,4-D are used instead of esters. Among the common farmcrops, flax is more tolerant of TCA than corn, wheat, barley, or soybeans.

Abnormalities

The common abnormalities that result from 2, 4-D are stem curvature, "fused" leaves, fused bolls, and fasciated stems. They are found in unsprayed plants but the frequency of occurrence is increased by 2,4-D. The first external change in plants is drooping or bending which begins within a couple of hours after spraying. These plants later straighten and regain a normal appearance unless they are very susceptible varieties or sprayed with excessive dosages, Sharma, working at Minnesota, found that the number of days required for recovery varied with the stage at which the flax was treated. There was no recovery of the varieties he worked with (Redwing, Dakota, and Minerva) when sprayed at full bloom; at earlier stages the period of recovery varied from 3 to 7 ½ days. He also found that the region of abnormality was higher on the plant as the stage of development at time of spraying progressed, indicating, probably,that there was a certain delicate region in the terminal bud which was affected by the chemical and that it moved up as the plant developed. Flax sprayed with recommended rates of MCP has not shown these abnormalities except an initial temporary bending. No such responses have been observed as a result of spraying with TCA although die-back, crinkling, and burning of the leaves sometimes happens.

Maturity

The response of flax to herbicides may be manifested in delayed maturity. Commonly blooming dates are delayed much longer than dates of ripening since Tandon, Paatela, and Sharma have all shown that the rate of elongation of flax sprayed with 2,4-D was greater than the check after the initial shock had been overcome. When tolerant varieties have been sprayed at recommended rates of 2,4-D and prior to the bud stage, Tandon and Sharma found dates of ripening to be delayed by only one or two days. In some seasons, flax becomes indeterminate in growth and full maturity may not be reached at all but, under these conditions, unsprayed and sprayed plants behave alike. Shulstad found, however, that relative delay in ripening was affected by variety and date of sowing. Thus, Minivera sown April 27 was delayed one day by 4 oz. of 2,4-D but 17 days when sown June 10. Redwing sown April 27 was delayed 2 days and only 3 days when sown June 10.

Delay from MCP has been less than from 2,4-D and delay from TCA at 7 lbs. per acre has occurred only from spraying during a 10-12 day period after emergence.

Yield

Although morphological responses indicate relative susceptibility to 2,4-D, they are not closely correlated with yield except when spraying is done at the full bloom stage. Furthermore, Shulstad showed that varietal response is affected by date of sowing. When 5 varieties of flax were sown at 10-day intervals over a period of 2 months, no one variety maintained its resistance or susceptibility in relation to the other varieties when measured by yield of seed. In fact, changes in relative positions were of such magnitude that no classification of a variety in its response to 2,4-D for all sowings was justified.

As a result of trials for three years with one variety and for two years with three varieties, spraying separate weed-free plots every other day from emergence of the flax until full bloom has shown that response to time of spraying varies with years. For example, in 1950 Redwood showed only slight reductions in yield regardless of when sprayed with two exceptions. In 1951, yields were reduced by most dates of spraying except just before bud until bloom; and in 1952, yields were reduced by all sprayings but most severely by those during the blooming period.

In similar trials, Redwood flax showed maximum reduction in yield when sprayed with 7 lbs. of TCA during the first 12 days after emergence. Yields following this period were not significantly lower than the unsprayed flax although they were less for a period of 26 days. From these and other trials, it has been observed that 5 lbs. of TCA are less damaging to the flax and adequate for control of Setaria spp.

In 1951, yields of seed were less than the check from plots sprayed with either 2,4-D or MCP in 44 out of 54 comparisons when weed-free flax was treated. In 20 out of 27 comparisons, however, yields were reduced only one-half as much by MCP as

2,4-D. MCP reduced the yields of B5128, a variety relatively susceptible to 2,4-D, only one-third as much as 2,4-D.

In all trils with 2,4-D, MCP, and TCA reported above, only flax kept weed-free by hand work was used. The reduction in yields due to the herbicide under such conditions is offset by injury from competition when weeds are present.

Quality

The percentage of oil and its iodine number may also be affected by the use of herbicides. Apparently, however, there are other factors which make it difficult to discover the relation of 2,4-D to these attributes of quality. In Tandon's study, the ester reduced both the oil content and the iodine number in 6 out of 7 varieties. When sodium and amine salts were used, Crystal and Minerva were most susceptible to reduction in oil percentage while in Koto, 4 oz. of amine did not reduce the oil percent and in Redwing even 8 oz. did not cause reduction. At the 4 oz. rate of amine there was no lowering of the iodine number of Dakota, Koto, Sheyenne, and B5128 but the ester reduced it from 3 to 13 units. In subsequent studies at Minnesota, the percent of oil has been reduced in 25 out of 64 comparisons by amines and 19 out of 47 comparisons by the ester. Average decrease for the amine is 0.41% and 0.58% for the ester. Maximum reduction was 1.2 percent for 12 oz. of amine on Koto at pre-bud stage and 2.2 percent for 1.3 oz. of ester on Minerva. The iodine number has been lowered in 32 out of 64 comparisons by the amine and 28 out of 47 by the ester. Average reduction is 2.8 for the amine and 3.9 for the ester. Maximum reduction has been 13 for 24 oz. of amine on Koto at late bud and 10 for 2.6 oz. of ester.

Paatela reports a consistent reduction in oil percent using sodium salt at 3 stages of growth. Heggeness and Le Tourneau show a 5 percent reduction in oil of flax sprayed in the bud stage. Friesen found no reduction in oil or iodine number in one year and a small lowering of the iodine number in another season. Klosterman and Clagett considered the differences in oil content between sprayed and unsprayed fields of three varieties were small. The iodine number of Minerva oil, however, was significantly reduced by spraying. Shulstad made oil and iodine-number determinations for 5 varieties of flax, sown at 7 successive dates, and sprayed with 8 oz. of a micronized at 2,4-D acid. He found no significant changes in either oil percent or iodine number as a result of spraying.

Last summer, we sprayed separate plots of Redwood with 7 lbs. of TCA at 2-day intervals from May 8 through June 7. Slight decreases in oil percentage were found in the first three stages; from cotyledon until the epicotyl was 0.8 inch long. A drop of 5.5 points in iodine number occurred when the epicotyl was 0.8 inch long and again when 2 inches long.

Plants Sprayed Through Several Generations

There has been considerable speculation as to whether plants sprayed with 2,4-D through several generations might develop either more or less tolerance to it. At Minnesota we sprayed Redwing, Minerva, and Redwood in 1949, their progenies in 1950, and their second generation progenies again in 1951 with 2,4-D amine. There has been no apparent change in response of these plants when compared to similar progenies whose ancestors were never sprayed.

NEW ASPECTS OF WEED CONTROL IN FLAX

W.H. Silversides, Winnipeg.

This paper is a brief review of the Western Canadian Experimental work with newer chemicals, used for the control of weeds in flax. Chemicals here reported on are MCP--TCA-- IPC-- Chloro IPC-- MH and combinations of TCA with 2,4-D and MCP.

At the University of Manitoba Burrows and Olson report that when 5 and 8 lbs of TCA acid Equivalent were used either alone or when mixed with 3 or 5 oz., 2,4-D amine-Foxtail control in flax was good to Excellent. The combined treatments gave excellent broad and grassy weed control. No damage to the flax was noted and significant flax yield increases are reported. Treatments were made when the foxtail was in the 1-2 leaf stage and the flax 2-3 inches tall. At Portage la Prairie, Manitoba, tests indicate that when 5.4 to 13 lbs. of TCA acid equivalent together with 4.4 oz. 2,4-D Amine when applied to weedy flax a significant increase in flax yields was obtained. Foxtail control was reported as excellent.

Breakey of the Dominion Experimental Station at Morden, Manitoba reports 100% control of Green Foxtail and Lambs Quarters was obtained when 5 lbs. TCA (90%) with 5 oz. of MCP Sodium salt were applied to weedy flax. Some Red Root Pigweed survived the treatment. Wild Buckwheat while set back later survived. Treated plots showed a 5.1 bu. per acre increase. The flax was 2-8 inches high and the foxtail 3 inches when treated. No damaged flax was noted. Rate of dilution was 11 gals per acre. Brown of the Dominion Experimental Station, Brandon, Manitoba treated weedy Rocket Flax plots with TCA--8 lbs -- TCA 5 lbs plus 5 oz. MCP Amine -- MCP Amine 5 oz -- CMU 2 lbs. -- Chloro IPC 5 lbs and MH 8 lbs. per acre. Chemicals were applied pre-emergently. It was found TCA at 8 lbs. killed 80% of the Millet with no ill effect on the flax. CMU at 2 lbs. killed 80% of the millet and 20% of other weeds present. Some flax injury noted. MH at 8 lbs. inhibited broad leaved weeds but did not injure the flax or grassy weeds. Chloro IPC at 5 lbs. inhibited all growth. A post-emergence second treatment was given these plots when the flax was 2 inches tall. It was found that TCA at 8 lbs. killed all wild millet with no injury to the flax or broad leaved weeds. TCA at 5 lbs. together with MCP at 5 oz. killed all of the weeds except Wild Oats. CMU at 2 lbs. killed all weed growth and severely injured the flax. Chloro IPC inhibited all growth. MH killed all growth. From these trials Brown concluded that TCA plus MCP appeared to be the only satisfactory chemicals to use for weed control in flax. Half of the above mentioned plots were plowed down in early July and reseeded to flax to determine the toxic residual effect. Plots treated with TCA were toxic. CMU at 2 lbs. stimulated the flax and at 4 lbs. thinned it. Chloro IPC acted as a strong stimulator and produced tall heavy growth. Maleic Hydrazide at 5 and 10 lbs. stimulated the second crop.

Foster and Molberg at the Dominion Experimental Sub-Station Regina used CMU at rates of ½ to 3 lbs. active per acre in 50 gals water per acre on weedy flax plots. The lowest rate had no effect on wild mustard and lambs Quarters. The application of ½-1-2-3 lbs. of CMU killed 10%-30%-75% and 99% of the wild mustard. Lambs Quarters was not affected. The treatment had little effect on the yield of the flax. Pre-emergence tests on the effect of TCA on Wild Oats using 10-20-30-40 lbs. acid equivalent per acre in 8½ gals of water per acre were also run. The TCA 10 lb. treatment did not reduce the Wild Oats but did

reduce the flax yield 42.5%. The 50 lb. treatment reduced the Wild Oat stand 58.8% and the flax yield 75.8%. Test at the Regina station have shown that wheat cannot be grown when 40 lbs. or more of TCA have been applied to flax the previous year.

Pavlychenko and Bestrop at Saskatoon applied MCP amine to weedy Victory flax (3-5 in. tall) at 3-4-5 oz. per acre. This treatment reduced broad leaved weed stands up to 50% and increased the yields of flax as much as 9.4 bu. per acre. Little delay in flax maturity was observed. When weedy flax was treated at the 7-8 leaf stage weed stands were reduced as much as 75%. Flax maturity was not delayed and treated flax plots yielded 2 to 3 times the check. Flax plots when treated with TCA at 10 lbs. per acre reduced flax yield 7%, at 15lbs. 24% and at 20 lbs. 10%. No material reduction in broad leaved weed stand was noted. Chloro IPC applied to weedy flax at 2-4-6 lbs. per acre reduced flax yields by 70--79-- and 91% repectively. IPC applied at 2-4-6 lsb. per acre did not significantly reduce the broad leaved weeds present. Janzen of the Dominion Experimental Station Swift Current, Sask., compared MCP Ester and Amine at 2-4-8 ozs per acre with 2,4-D Ester in weedy flax. The flax was treated at the 5 leaf stage. Chief weeds were Russian Thistle, Stinkweed and Red Root Pigweed. Both MCP forms failed to control Russian Thistle, while the Stinkweed was controlled in all of the treated plots. The 2,4-D ester at the 2 oz rate gave partial weed control and practically complete control at the 4 oz rate. All flax plots showed a delay in maturity with the 8 oz. 2,4-D Ester showing the most. MCP treated plots showed no injury to the flax while the 8 oz of 2,4-D Ester caused considerable damage.

Coupland of the University of Saskatchewan ran tests using MCP Amine and 2,4-D Ester formulations on weedy flax at 4 and 8 oz. per acre. Results indicate MCP appears to have no advantage over the 2,4-D treatment.

Friesen of the Dominion Experimental Station at Scott reports the comparison of MCP Sodium, Amine and Ester with 2,4-D Amine and Ester when applied to weedy flax. The main weed was Stinkweed and the rates used 2-4-6-8 ozs per acre. The MCP gave slightly better Stinkweed control. The 2,4-D killed Russian Thistle in the plots while the MCP did not. Flax treated with 2,4-D delayed flax maturity as much as 12 days while MCP delay was only 4 to 5 days.

Craig and Silversides of Winnipeg ran cooperative tests at six locations in southern Manitoba. Chemicals used were TCA at 2½-5-10 lbs, CMU at ½-1-2 lbs., Chloro IPC at 1 lb., TCA and 2,4-D 5 lbs and 5 ozs and TCA and MCP 5 lbs and 6 ozs. All of the TCA treated plots gave 85% or better control of Wild Millet. The TCA-2,4-D and TCA-MCP treated plots showed excellent control of both broad leaved and grassy weeds(Setaria). Some reduction in Wild Oat stands was noted. Plots treated with CMU and Chloro IPC showed no appreciable effect on either the crop or the weeds.

In Summary it would appear from the co-operators reports that

1.- T.C.A. at rates of about 5 lbs per acre together with 5 oz. of 2,4-D Amine or MCP give satisfactory control of foxtail and susceptible broad leaved weeds in flax crops.

2.- The optimum stage of growth of flax for treatment appears to be when the flax is 3-5 inches tall and the foxtail less than two inches high.

3.- The limitations of MCP should be recognized, namely its inability to control Russian Thistle.

4.- The sterilizing effect of T.C.A. on crop land at dosages of 40 lbs. and up should be appreciated.

5.- The use of Chloro IPC- IPC- CMU and MH for the control of weeds in flax at the rates used does not indicate that they have an immediate place in weed control in this crop.

6.- Indications that TCA will reduce stands of Wild Oats have been noted and more work on rates and time of application needs to be done.

7.- Amount of water used in TCA application seems to have little or no bearing on results obtained.

PHYSIOLOGICAL ASPECTS OF MICRO-NUTRIENT SPRAYS AND DUSTS

D.J. Wort, University of British Columbia

Given the correct climatic environment, particularly the correct temperature and photoperiod, the proper growth of a plant demands an adequate supply of minerals and requires sufficient carbohydrates, synthesized during photosynthesis, to furnish the bulk of its chemical constituents. The whole growth process is made possible by enzymes and is integrated by plant hormones. The temperature and photoperiod cannot be changed on a large scale in the field but through the mineral supply there are possibilities of altered photosynthesis, enzymatic action and formation of hormones.

Information on the functions of mineral elements within the plant has been furnished by the new biochemical approach which attempts to identify an element as an essential cellular constituent or to discover its participation in biochemical reactions. The suspected catalytic action of the micronutrients has been clearly shown. Most enzymes consist of a protein portion, which gives specificity to the enzymes, and of a non-protein part called the prosthetic group. This portion is responsible for the activity of the enzyme.

A number of the micronutrients commonly used in foliar feeding form the prosthetic groups of various enzymes, and thus confer activity. Copper is the prosthetic group of some respiratory enzymes, for example polyphenol oxidase and ascorbic acid oxidase; zinc of carbonic anhydrase. Peroxidase, catalase, cytochrome and cytochrome oxidase have iron in their iron-porphyrin prosthetic groups.

The microelements may have less specific roles as enzyme activators. Hexokinase requires magnesium to activate it and arginase is activated by manganese, cobalt, nickel, or iron. Carboxylase, which is concerned with carbon dioxide use or release, needs manganese, magnesium, iron, cobalt, nickel, or zinc, while isocitric dehydrogenase, one of the respiratory enzymes, is activated by manganese or magnesium.

The growth-regulator, auxin, is derived from tryptophane, which in turn is dependent upon zinc for its production. Zinc also seems necessary for the synthesis of pyruvic decarboxylase. It has been suggested that iron is required for the formation of the chlorophyll-protein complex. The reduction of nitrate, necessary for protein synthesis, is influenced by both manganese and molybdenum. One of the reactions in photosynthesis, the photochemical evolution of oxygen, may be catalyzed by zinc, iron, cobalt, nickel, or copper. Thus we see that the microelements and some of the macroelements too, influence such vital activities as sugar synthesis and its transformation, respiration, and organic acid formation in the plant.

The study of mineral nutrition in relation to

ontogeny suggests additional ways whereby the metabolism of the plant may be influenced by application of minerals. In spite of diversity of plant types and environmental conditions, there are many similarities in the developmental physiology of annuals. The three stages in the life history of an annual are the vegetative, the flowering, and the fruiting stage. Each stage has its own metabolic characteristics.

The vegetative stage is characterized by high intake of inorganic nutrients, rapid synthesis of proteins, and high auxin levels. The soluble carbohydrates provide the respiratory energy for the intake of ions by the roots, for the reduction of nitrates and for synthesis in general.

Sporogenesis marks the beginning of the flowering period. An initial interval of systemic acceleration of catabolic processes and rapid salt absorption is followed by the decline of metabolic activity associated with flowering. Associated with syngemy and early fruit development there is a resurgence of absorption of minerals and organic sythesis. The growth rate of shoot and fruit may be temporarily limited by an impairment of conduction resulting from structural modifications of the vascular tissues.

The final stage, fruiting, is marked by an early increased absorption by the roots and increased accumulation of proteins and carbohydrates. During the early fruiting stage many species exhibit a high absorptive capacity for and extreme sensitivity to changes in nutrient supply. Response to fertilizers made available at this time are often quite dissimilar to those resulting from fertilizers supplied at earlier or later stages. From the foregoing it is evident that stage of development will determine the response of a plant to mineral application and a study of these responses is necessary for the correct timing of fertilizer application.

Although it is common agricultural practice to correct nutritional deficiences by soil fertilization, the complex nature of soil makes it difficult to interpret the plant response. The effect may be direct, as when the element is absorbed by the plant, or the effect may be an indirect one. The nitrogen of ammonium compounds is usually taken into the plants in the form of nitrate formed from ammonia by bacteria in the soil. An element may increase nitrogen fixation, or may enter into ion exchange reactions which result in the absorption of other ions by the plant, or which result in an altered soil condition.

An element may be abundant in the soil yet be unavailable to the plant. The fixing power of the soil is very high. In a peach orchard in California there were 3000 pounds of zinc per acre within the root zone yet the trees showed zinc deficiency. In another soil the application of 1500 pounds of zinc sulfate failed to cure zinc deficiency in apples. The status of zinc was demonstrated in these cases by foliage spraying. As will be mentioned later, there may be a high content of an element within the plant, yet the plant may show deficiency symptoms of that element. It may be "fixed" within the plant and so unavailable for use in growth.

Foliar application of nutrients is a practical method and has been widely used in treating micronutrient deficiencies in the field. Zinc, boron, molybdenum, manganese, magnesium, copper, and even full nutrient sprays have been used very successfully.

That foliar applied elements are readily absorbed and translocated has been demonstrated by the use of radioactive isotopes. The most rapid movement apparently occurs during the day and the final distribution is comparable to that obtained when minerals are taken up by the roots. It has been shown that meristems are first to suffer deficiencies when calcium, boron, iron and others are involved. An interesting feature was that symptoms of malnutrition are as often due to failure in the distribution system as to failure in the initial absorption.

Foliar application has a number of advantages over soil application of the same nutrients since 1) it is economical - a higher percentage of the nutrients is absorbed. 2) It is fast acting - the elements are applied at or near the region of the plant where they will be used. The translocation problem is lessened. 3) It admits of timed application. Depending upon the effect desired, application could be during the early vegetative stage, the early flowering stage or early fruit development. The exact time and the composition of the dusts or sprays will have to be discovered by thorough investigation.

Supported by a grant from the University of British Columbia Research Fund, an experiment was undertaken at the University wherein Marquis wheat, Victory oats, Trebi barley, and Masterpiece bush beans were sprayed with a variety of nutrient solutions at three different times during the growing season. Observations were made on 1) effect on heading, flowering and ripening of the cereals 2) yield 3) straw 4) protein content of seeds 5) phosphorylase, catalase and carbonic anhydrase activity.

On May 21, 1952 each cereal and the beans were sown in rows twenty-two feet long and nine inches apart (cereals) or eighteen inches apart (beans), in plots twenty-two feet by thirty feet. Each row was divided into four parts for early, middle and late sprays and for control. The plants of five complete rows also served as controls. The plots were replicated five times for each kind of seed.

The elements, given in the table, were applied in a 0.1% Tween-20 solution by small hand aspirators at the rate of 4.7 ml. per square yard. This rate is equivalent to the application of 5 gal. of 1000 p.p.m. 2,4-D per acre. Cardboard boxes were placed over the portion of the row to be treated to prevent drift. Application of the sprays to the cereals was on June 3 (early vegetative stage, height 5 inches), and on June 18 (flower primordia present). Barley was sprayed on July 7, wheat and oats on July 17 (syngamy occuring). Beans were sprayed June 12(first trifoliate leaves opening) and on July 18.

The sprays, made up in 0.1% Tween-20 (to insure thorough wetting of the foliage) were as follows:

SPRAYS

Element	Compound used	Concentrations (p.p.m.)
# Boron	Boric acid	500 1000 1500
Molybdenum	Mo sulfate	100 200 300
# Copper	Cu sulfate	200 400 600
Zinc	Zn sulfate	500 1000 1500
# Iron	Fe citrate	1000 2000 3000
Manganese	Mn sulfate	500 1000 1500
#Magnesium	Mg sulfate	500 1000 1500
Mo + B		200 + 1000
Mo + Cu		200 + 400
Mo + Cu + B		200 + 400 + 1000
Cu + B		400+1000
#Fe + Cu		2000 + 400
# 2,4-D	Am 2,4-D	500 (10 for bean)
# " +Cu		500 + 400
# " +Fe		500 + 1000
# " +Mg		500 + 500
# Macros	KH_2PO_4 +	2000 +

	$MgSO_4$ + $Ca(NO_3)_2$	2000 + 4000
# Micros	Fe + B + Mn + Cu + Zn	1000+1000+1000+400+1000
# Complete	Macros+Micros	
Tween-20	Tween-20	0.1%

All applied to wheat, oats, and barley
Those marked # applied to beans.

The cereals were harvested when dead ripe - barley Aug. 15, oats Sept. 1, and wheat Sept. 15. The beans were harvested on Oct. 1, 1952. Data for total weight (straw plus grain), number of plants, and number of tillers per plant were recorded at harvest and the threshing partially completed at that time. Subsequently the data on yield per plant, straw per plant, etc., have been accumulated. All the data are not available at the present. Thus the results given are incomplete.

The results, obtained to date, are as follows:

1) No appreciable difference in time of heading, flowering and ripening between treated and control cereals and in beans.

2) Yield increases: Barley: Early application - Magnesium 1000, Manganese 1500; Middle application - Magnesium 1000, Molybdenum 300, Molybdenum plus boron; Late application - Molybdenum 300, Molybdenum plus copper, 2, 4-D plus magnesium.

Wheat: (single element yields not recorded): Early application - Molybdenum plus boron, molybdenum plus copper, 2,4-D plus magnesium. Middle application - Molybdenum plus copper. Late application - none.

Oats (single element yields not recorded): Early application - Molybdenum plus boron, molybdenum plus copper, molybdenum plus copper plus boron. Middle application - Molybdenum plus boron, molybdenum plus copper plus boron, 2,4-D plus iron. Late application - Molybdenum plus copper plus boron.

3) Straw increases: Wheat: Middle application- Molybdenum plus copper, micro elements, 2,4-D in all combinations.

4) Protein content (from early application) increased by 2,4-D in wheat and barley and by copper in beans.

5) Enzymes: Phosphorylase: oats, late spray - slight increase with magnesium 1000. (treated/control = 1.1)

Catalase: oats, late spray - slight increase with 2,4-D and with iron plus copper (treated/control = 1.4) Considerable increase with iron 3000 (treated/control = 2.8) and with iron plus 2,4-D (treated/control = 3.3)

Carbonic anhydrase (wheat, oats, barley): preliminary runs show slight increase with zinc sprays.

Based upon available data, it can be said that the most promising application was that of molybdenum, singly or in combination. This was the only element whose application resulted in increased yields in all three cereals and in an increased production of straw by wheat. Magnesium alone and in combination produced increased yields in barley.

It is hoped to repeat portions of the experiment in 1953 and to use additional combinations of elements.

2,4-D WITH ADDITIVES OF LEAF-FEEDING PROPERTIES

P.O. Ripley, Central Experimental Farm, Ottawa.

The idea of using chemicals, jointly, for plant feeding and herbicidal purposes is not new. As early as 1922 sulphate of ammonia usually looked upon as a nitrogenous fertilizer was used as a herbicide to kill dandelions in lawns. Calcium cyanamid also a nitrogenous fertilizer was used quite successfully in 1936 to kill mustard in grain fields. Potassium cyanate has been used to kill some plants, but will promptly decompose in the soil to form ammonia and potassium carbonate. Ammonium sulfanate spray will kill some plants but by chemical reaction in the soil is transformed into ammonium sulfate and ammonia. Borax has been used to correct certain physiological disorders in plants, but is also a very effective herbicide.

The providing of plant nutrients through the leaves of plants is an established and accepted practise. Foliage spray applications have been largely confined to trace elements such as boron, manganese, magnesium and zinc. Deficiencies of such elements in the plant are frequently due to lack of availability rather than to actual deficiency in the soil.

Boron has been sprayed on the leaves of turnips at the Ontario Agricultural College, Guelph, and at the Central Experimental Farm, Ottawa, to successfully control brown heart. Boron as a foliage spray has also been used to control water core of apples. Magnesium and manganese sprayed on the leaves of plants have satisfactorily supplied these nutrients where these elements were needed. It has been demonstrated that spraying with urea to add nitrogen has benefitted apple trees and wheat. Turrell and Chervenak by using radio active sulphur have shown, that, when dusted on citrus trees to control insects, some of the sulphur was absorbed by the plants as a nutrient. Copper dusts have been effective in controlling deficiencies of this element in the everglades region of Florida. A very complete review of the work done in connection with the use of combination fertilizers and Pesticides, dusts and sprays has recently been contributed by Mehring, of the U.S.D.A.

A number of combinations of 2,4-D and fertilizer have been reported recently. Longchamp and Gautheret in France, increased grain yields by supplying 2,4-D in mixed fertilizers at planting time, but decreased yields by applying the 2,4-D later as a spray. Matskov and Podrahanskaya increased the yield of wheat 21 percent by adding 2,4-D to fertilizer as compared to fertilizer alone. In United States one of the first such mixtures was introduced in 1947, now there are a large number of distributors offering them for sale. One multiple mixture has been reported in New York State which is said to consist of grass seed, compost, chemical fertilizer, chlordane, a fungicide, a crab grass killer and a weed eradicator.

Several combinations of 2,4-D and fertilizer mixes have appeared on the market in Canada. One such mixture has been developed in Western Canada and sold as a combination leaf feeding dust and 2,4-D. Great claims have been made for this product based on a number of observations and tests carried on by the producer. A few semiofficial tests were made with the

mixture in 1951 and the work was expanded to a larger number of official tests in 1952. The remainder of this paper will deal with information obtained as a result of these tests.

Four different combinations of leaf feeding dusts and 2,4-D were supplied by the producer in most of the tests, but for purposes of brevity and simplicity only one, or in some cases two, standard form will be discussed. In all cases this combination dust was compared on the basis of its effect on crop yield with a standard 2,4-D dust and with check plots receiving no treatment. No record of its effectiveness as a herbicide was taken since the information sought was its effect on the crop grown. Experimental work was done at the University of Manitoba, Winnipeg, the University of Saskatchewan, Saskatoon and the Canada Department of Agriculture Stations at Brandon and Melita in Manitoba, Indian Head, Regina and Scott, Saskatchewan and Lethbridge in Alberta.

University of Manitoba.

At the University of Manitoba the test was conducted in small plots in a Latin square design and the dust was applied with a hand duster. Weeds were removed to eliminate the effect of plant competition on yields. Both "fortified dust" and 2,4-D alone were applied at 2 rates in 1951, and 1 rate in 1952. Results on wheat and flax in 1951 and 1952 are shown in Table 1.

Brandon and Melita, Manitoba.

At Brandon and Melita plots 10 x 15 feet were laid out in a 5 x 5 latin square design. Comparisons included a check plot with no treatment, standard 2,4-D dust 10% at 12 pounds per acre, fortified A dust 10 percent at 12 pounds and fortified B dust 10 percent at 12 pounds per acre. The dust was applied with a hand duster. The yields are shown in Table 3.

No significant difference in yield was obtained between treatments at Brandon or Melita.

Indian Head, Saskatchewan.

At Indian Head field plots were laid down and the dust was applied with a large commercial duster. The various treatments were applied at 7 pounds per acre to wheat, oats, barley and flax at two stages corresponding approximately with the 3 leaf and 6 leaf stage of wheat. The treatments were not replicated and yield data was taken on the basis of 8 yard square samples in each treatment and compared on a paired plot basis with similar samples from the check plots. The yield data are shown in Table 4.

The fortified 2,4-D dust gave a significant increase in yield over both check and 2,4-D alone treatments on early treated wheat and late treated oats. The 2,4-D treatment yielded significantly lower than the check on early treated barley. Otherwise there was no significant difference in treatments, although the average yields tend to show a trend in favor of Fortified 2,4-D.

Table 1 - Results with leaf feeding dusts at Winnipeg.

Crop	Year	Check	2,4-D	Fort. 2,4 D	2,4-D	Fort. 2,4-D
			(4 ounces)		(8 ounces)	
Wheat	1951	53.4	54.1	52.6	52.3	52.8
				(6 ounces)		
Wheat	1952	59.2	54.6A	57.2A	57.5B	57.2B
			(3 ounces)		(6 ounces)	
Flax	1951	34.6	37.9	36.1	36.4	35.9
				(3 ounces)		
Flax	1952	23.6	20.2A	20.6A	24.0B	21.1B
			Field Trials Soils Department Oak Bank - 5 ounces application.			
Wheat	1952	34.0	35.9	36.4		
Wheat	1952	37.8	35.9	39.2		

The difference between any two treatments means in the Winnipeg tests were not significant at the 5% level.

University of Saskatchewan, Saskatoon.

At the University of Saskatchewan a Commercial mixture of 2,4-D dust and "fortified" 2,4-D dust was compared with two home mixed dusts. The dust was applied with a commercial duster in strips 33 feet wide. Ten paired square yard samples were taken from each set of adjacent strips. The results from the Commercial mixtures are presented in Table 2:

Regina, Saskatchewan.

At Regina, Saskatchewan, the dusts were applied with a conventional field duster on 1/58 acre plots. The plots were in triplicate and wheat, oats, barley and flax were treated two weeks after emergence and five weeks after emergence. The yields were as shown in Table 5.

Table 2 - Results at Saskatoon, Saskatchewan.

	Check	2,4-D	"Fortified" 2,4-D
Bushels per acre	41.7	40.5	38.3

The 2,4-D treatment produced an average yield lower but not significantly lower than the check. The yield following treatment with "fortified" 2,4-D was significantly lower than the 2,4-D alone.

Table 3 - Results at Brandon and Melita

Station	Crop	Check	2,4-D	Fort. A 2,4-D	Fort. B 2,4-D
Brandon	Wheat	33.5	31.0	31.8	30.8
Brandon	Barley	56.5	58.8	58.2	57.1
Melita	Oats	95.3	90.9	90.4	-

Table 4 - Yield data at Indian Head, Saskatchewan.

Crop	Application	Check	2,4-D	2,4-D & Fort. A.
Wheat	Early	31.1	27.7	36.8 +
	Late	33.1	27.8	31.4
Oats	Early	87.0	69.4 -	83.6
	Late	75.2	73.1	89.9 +
Barley	Early	63.7	48.7 -	59.8
	Late	56.2	52.1	62.5
Flax	Early	15.0	18.0	18.4
	Late	17.1	15.1	20.0

\+ Significant increase over check.
\- Significant decrease over check.

Table 5 - Yields at Regina, Saskatchewan.

Crop	Application	Check	2,4-D	2,4-D + Fort. A.	L.S.D.
Wheat	Early	48.3	43.5	44.2	
	Late	46.4	42.5	44.2	
Oats	Early	126.2	109.3-	110.6-	9.86
	Late	117.0	109.9	113.7	
Barley	Early	84.7	76.3-	76.2-	6.8
	Late	82.8	75.1-	79.5	6.8
Flax	Early	11.0	12.1	11.7	
	Late	12.0	13.0	13.3	

\- Significant decrease over check.

Table 6 - Yields at Scott, Saskatchewan.

Crop	Check	2,4-D	2,4-D + Fort.
Wheat	33.9	29.6-	31.9
Oats	90.1	97.8	88.8
Barley	42.7	39.6	42.7

The 2,4-D applied to wheat was the only treatment which showed a significant difference in yield in those data shown in table. 6.

Table 7 - Yields at Lethbridge, Alberta.

Crop	Application	Check	2,4-D	2,4-D + Fort.	L.S.D.
Wheat	Early	43.6	44.8	43.4	
	Late	43.3	45.4	43.1	
Oats	Early	41.9	44.3 +	41.9	2.2
	Late	40.2	44.2 +	43.1 +	2.2
Barley	Early	51.2	50.3	48.5	
	Late	47.9	51.4	50.2	

Both 2,4-D and Fortified 2,4-D significantly decreased the yield over check on early treated oats and early treated barley. The 2,4-D also reduced the yield of late treated barley. Otherwise no significant differences are evident from the data at Regina.

Scott, Saskatchewan.

At Scott, Saskatchewan the test was laid down in plots 16.5 feet by 120 feet, with a 9 foot check strip beside each plot. The dust was applied with a single boom 16.5 foot field duster. The dusting was done when the oats and barley were in the 2 to 3 leaf stage and the wheat was in the 3 to 4 leaf stage. Yields were determined harvesting 10 square yard samples from each treated strip and 10 samples from its adjacent check strip. The yields are shown in Table 6.

The 2,4-D applied to wheat was the only treatment which showed a significant difference in yield in those data shown in table 6.

Lethbridge, Alberta.

At Lethbridge a field test was laid down in quadruplicate plots. The dust was applied with a standard boom duster at 7 pounds per acre, and applications were made at two stages, approximately the three leaf and six leaf stages. Yields were computed from the plots harvested with a self propelled combine and are shown in Table 7.

At Lethbridge 2,4-D applied at the early date on oats and both 2,4-D and "fortified" 2,4-D on oats at the late date produced significant increases in yield over the untreated check. No other treatment produced significant differences.

In addition to the results presented above a number of other formulations of "leaf feeding dusts" were compared, but showed practically no significant differences in yields from the treatments. Also a number of tests were conducted at Lethbridge, Regina, and Scott, using a tent arrangement to confine the dust to a small prescribed area. Again no significant differences were noted.

In summary and conclusion it is suggested that the information from the rather extensive field experiments presented above provide no basis on which to recommend the use of "fortified" 2,4-D dusts or 2,4-D with additives of leaf feeding properties over standard 2,4-D herbicide applied alone. It is suggested that further experimental work should be undertaken in connection with this problem.

NEW ASPECTS OF WEED CONTROL IN FLAX IN THE UNITED STATES.

W.P. MacDonald, Minneapolis.

Because of its growth habits, flax has long been recognized as a crop likely to lose out when subjected to competition from weeds. Early in the agriculture of what is now the principal flax growing region of the United States, it was accepted that the seeding of flax should be confined to land freshly broken from the prairie sod. When no more virgin soil remained, seeding of the crop was largely confined to new fields which had been seeded down to tame grasses or legumes for several seasons. Only in fairly recent years has it become profitable to produce flax on what is commonly referred to as "old ground". The previous limitation imposed on flax production was not due to a lack of nutrients in regularly cropped soil, but rather accounted for by the almost certain presence of an abundance of weeds. Flax offers little competition to weeds in its early stages of growth. Advisedly, or otherwise, many flax producers refrain from seeding in the spring until the ground has warmed up, a practice which may be of questionable benefit to the flax crop, but most certainly serves to promote a rapid and vigorous growth of weeds. As the flax plant is not a heavy producer of foliage, it does little to resist weeds throughout the growing season, and quite often as the crop matures, weeds take a new lease on life and greatly complicate harvesting.

Intelligently applied cultural practices should be the backbone of any weed control program for flax production. One of the soundest cultural approaches to the weed problem in flax has been the widespread acceptance of August tillage in anticipation of seeding flax the following year. Such early tillage immediately following removal of the current crop does much to promote the fall growth of weeds, which normally will be killed by freezing or in the event of a late fall can be eliminated by cultivation. Fairly recent experimental work on flax production has also revealed that it is safe to plant flax about as early as spring wheat. Only rarely is the flax crop lost due to spring frosts. Early seeding helps to reduce the initial competition from weeds.

In the last few years flax production has been made much more certain by the judicious use of several weed control chemicals. Originally it was presumed that flax would not survive applications of 2,4-D simply because it is a broad-leaved plant. Investigators soon learned that while flax is susceptible to injury from 2,4-D at rates which may safely be used on small grain, it does have a degree of tolerance which permits elimination of several of the worst weeds which limit production. It is now common practice to use three or four ounces acid equivalent of amine 2,4-D per acre or approximately one-half of that amount of the ester type. Flax may be sprayed with this quantity of herbicide as a post-emergence spray anytime after it has developed four or five true leaves and up to the pre-bud stage. Early spraying is generally preferred provided a majority of the weeds to be controlled have emerged. Spraying the crop after bud formation may cause superficial or real damage. Such injury may be manifested by abnormalities of growth, delayed maturity and reduced yield.

Last season brought the first general use of MCP for weed control in flax. Investigators, particularly at the University of Minnesota, have observed that in general, MCP gives control of the broad-leaved weeds common to flax, equal to that obtained with like dosages of 2,4-D, with less possibility of injury to the crop. From several sources it has also been reported that when spraying flax, four ounces of MCP acid equivalent per acre has given better control of Canada and sow thistle than has the same quantity of 2,4-D acid. At the same time a number of observations have been made that under field conditions, flax does not show any measurably greater tolerance to MCP than to 2,4-D, and this coupled with the lower cost of the latter has tended to keep farmers from changing chemicals. It has also been pointed out that in the flax growing valleys of California where flax will tolerate as much as three-fourths pound of 2,4-D acid equivalent per acre, that chemical has given better weed control than has MCP at the same rate.

Acceptance of TCA for the control of annual grasses, other than wild oats, in the north central region of the United States became widespread last season. Generally recommended rates of application were from six to eight pounds of a 90% sodium TCA per acre. Excellent control of pigeon grass, or green and yellow foxtail, (setaria spp.) has been

obtained at these rates. The chemical is applied as a post-emergence spray, preferably when the grasses are one to two inches high, and if at all possible before they have reached a height of four inches. Pre-emergence treatments can also be successful but growers ordinarily will not apply a control when they have no certain knowledge that there will be a weed problem. For post-emergence control, stage of growth of the flax does not seem to be of primary importance, but when the grass has attained the heights mentioned the flax will usually be two to six inches tall. Results with TCA have generally been much more dramatic when the soil is moist at the time of application or when light to moderate rains are received following treatment. Where drouthy conditions prevail, or where the grass has attained a height of five or more inches, the action of the chemical is likely to be very slow or unsatisfactory. Liquid TCA preparations have also been used with equal success when applied on an active ingredient basis comparable with that recommended for the dry products. There has been some consumer objections to fumes sometimes present when using liquid TCA. An important objection to using the dry sodium TCA has been the difficulty encountered in getting it into solution with water, particularly when high concentrations are used. All TCA preparations are somewhat corrosive to metal.

For the first time many flax growers this year tried combinations of TCA and 2,4-D, or MCP, as a "one-shot" treatment to control both broad-leaved and grassy weeds in flax. When such combinations were applied each chemical was used at the rate generally recommended for its use alone. According to the vast majority of observations such applications were very satisfactory. In a few instances damage to the flax crop resulted from the combination. Information released by The Dow Chemical Company reveals that when TCA and 2,4-D, or MCP, at recommended rates are added to a given quantity of water, the surface tension of the resulting solution is lower than when TCA or either of the hormone type herbicides is used alone. This may very well result in more wetting of the flax plant which could account for a tendency of the combination of chemicals to be more damaging. Scattered reports from farmers has pointed to more injury from MCP and TCA than when 2,4-D and TCA were used. This observation has not been borne out by controlled experiments and is not supported by the theory of more wetting, as in the only results reported to date the surface tension of the 2,4-D and TCA combination appears to be lower than that of TCA and MCP. As long as there is some possibility of injury when using TCA and one of the hormone type herbicides it would seem prudent to recommend that users limit such mixtures to the minimum recommended quantity of each chemical.

In 1952, probably for the first time, CMU was applied to flax in an effort to control wild oats. In one set of trials CMU was applied as a pre-emergence spray at the rates of two, four and eight pounds per acre. In another trial the chemical was used as a post-emergence spray at the same rates. In both instances control of wild oats was satisfactory at the two higher rates. At the highest rate there was some injury to the flax, but in the post-emergence series the flax yield still exceeded that of the check. Certainly recommendations can not be based on the very preliminary work with CMU this year but these results should encourage additional studies in future seasons. In connection with wild oats control in flax, it is interesting to note that two observers working independently, obtained an erratic but appreciable degree of weed control using TCA and 2,4-D or MCP combinations.

While IPC has not shown much promise in the north central states it is recommended for the control of certain weeds of flax in California, particularly wild oats and canary grass, when applied at three to four pounds of the 50% wettable product with about thirty gallons of water per acre. In California IPC has also been used in combination with 2,4-D to control both grasses and the broad-leaved weeds, but may result in some injury to the crop.

For pre-harvest weed control in flax, dinitro materials and PCP have shown a great deal of promise and if improved techniques of application can be developed could result in a great deal more of the northern flax acreage being straight combined.

With reference to methods of application, the hormone type chemicals have been applied very effectively with both ground equipment and airplanes. With either type of equipment the quantity of diluent appears to be unimportant but uniformity of application of the active ingredient is all important. TCA and combinations of TCA and 2,4-D or MCP, has been successfully applied by aircraft in some instances during the past year. However, the percentage of successful treatments with aircraft using TCA, or the combination of chemicals, has reportedly been somewhat less than when ground equipment was used. This probably is accounted for by the desire of air operators to use an absolute minimum quantity of carrier, which may result in unequal distribution of the chemical. When ground equipment is used for the application of TCA, or a combination of chemicals including TCA, most recommendations have suggested five to ten gallons of water per acre with emphasis on the higher rate. In one set of controlled experiments in 1952, TCA alone and in combination with 2,4-D at the recommended rates was applied to flax in two, four and eight gallons of water. The lowest rate produced what appeared to be rather severe burning immediately following application, However, there were not significant differences in final yields. It does appear that there will be greater consumer satisfaction if the quantity of water used with TCA does not go below five gallons per acre.

Probably greater strides have been made in developing effective weed control methods for flax than for any other crop commonly grown in the north central area of the United States. Any flax grower, actual or potential, would be well advised to study recent developments in this field as a good many of the limitations previously imposed on flax production by weeds have been removed.

DOMINION-FINANCED WEED SURVEYS IN WESTERN CANADA, 1952.

Robert T. Coupland, University of Saskatchewan.

Weed surveys in the four western provinces are being financed by the Canadian Department of Agriculture through grants provided under an extramural research project of the Science Service. These surveys have been conducted in the Prairie Provinces for four years and in British Columbia for two years. In three provinces the provincial department of agriculture has taken responsibility for conducting the survey and has employed undergraduates on a seasonal basis to conduct the field work. In Saskatchewan the University is responsible for conducting the survey, graduate students being employed throughout the year in a coordinated program of study of persistent perennial weed species of which the survey is just a part. The following is an interim report of the results of the survey in each province for 1952. Reports of previous years'

work will be found in proceedings of the Western Canadian Weed Control Conference beginning in 1949. The present report is compiled from information supplied by N.F. Putnam (B.C.), G.R. Sterling (Alta.), the writer (Sask.), and H.A. Craig (Man.).

British Columbia

One survey started from Osoyoos in the Southern Okanagan, which was completed in 1951, and extended eastward across the southern portion of the province to the Alberta border. The areas included the Boundary area around Grand Forks, the Nelson-Trail-Castlegar area in the Arrow Lakes, the Creston area around Creston, and the Rocky Mountain Trench from Golden south through Kimberley, Cranbrook and Fernie to the United States border. This whole area of about 800,000 acres is generally referred to as the Boundary-Kootenay area.

The second area surveyed in 1952 completed the Thompson Valley-Nicola-Fraser Valley area between the two areas completed in 1951 (i.e., the North Okanagan and the Cariboo). The surveyed area in 1952 included the South Thompson and North Thompson Valleys to Kamloops, the Thompson River Valley and its junction with the Fraser River at Lytton, the Fraser River Valley from Lillooet through Lytton to Spences Bridge and from Spences Bridge through the Nicola range country to Merritt and north to Kamloops. This whole area of about 1,600,000 acres is primarily range country with limited areas of cultivated land for feed production. Smaller areas along the Thompson River near Kamloops are devoted to fruit, canning crops, potatoes and dairying.

The paper included details of infestations.

Alberta

The area surveyed in 1952 included three municipal districts (Nos. 14,40 and 136) with a combined area of about 880,000 acres. Two of these are in the southern part of the province, while one is in the north (Peace River Region).

Toad flax was found in all three areas to infest a total of 30 quarter sections. Only three of these infestations were extensive, the other 27 being limited to single patches ranging in size up to 100 sq. ft. in area.

Hoary cress was found in one municipality where it infests between 100 and 120 quarter sections. Only in 18 to 20 of these does the infestation exceed one-half acre in extent.

Russian knapweed was found to infest two municipalities, a total of five patches being found ranging up to 500 sq. ft. in area.

Field bindweed was found in seven quarter sections in one municipality. Only one of these was severely infested. Two patches of hedge bindweed were also reported.

One small patch of bladder campion was found.

Perennial sow thistle and Canada thistle were found in all three municipalities but apparently constitute a problem only in one of the southern municipalities (No. 40).

Saskatchewan

During 1952 original surveys were made in 12 rural municipalities, resurveys were conducted in three rural municipalities and a preliminary transect was run through three other municipalities.

A summary of the infestations found and mapped in the area covered by the detailed survey is presented in Table 1. The municipalities involved are Nos. 137,164,166,195,231,314,344,372,373,374,404 and 405. Accumulative data for the first four years of survey are summarized in Table 2. See Page 26.

The data in Table 2 are applicable to the extent of the infestations of each weed in the 70-municipality area (one-fifth of the settled part of the province) at the time the survey was made whether in 1949,1950, 1951 or 1952. Obviously changes have taken place since the early surveys. Resurveys have consequently been made in one municipality in 1951 and in three in 1952 which were first surveyed in 1949. When the data obtained from these surveys are included they indicate that a minimum of 3310 quarter sections are infested by a minimum of 63,340 patches of toadflax, involving an area of at least 70,000 acres within the 70 municipalities so far surveyed in Saskatchewan. A comparison of these conservative data with those of Table 2 indicates the extent to which this species has spread since the initiation of the survey in 1949.

An indication that the survey is not having difficulty in finding infested areas of all species is shown by the fact that the average number of infested quarters located per municipality was 34 in 1952 with an average infested area of 9 acres per quarter section.

A preliminary survey was made in R.M. Nos. 227, 257 and 287 to ascertain the abundance and distribution of poverty weed in that region. The data have not yet been summarized.

The extension work conducted in connection with this survey is considerable. It is estimated that the weed problem was discussed in 1952 with about 2,000 farmers on their own land. In addition four field days were attended for the purpose of presenting addresses on the persistent perennial weeds.

Manitoba

Surveys were made during 1952 in five rural municipalities and in a number of suburban municipalities surrounding the city of Winnipeg.

Leafy spurge was located in a total of 152 quarter sections in three rural municipalities (Stanley, Brenda and Cameron). Infestations were considered to be a trace (up to two or three patches) in 51, light (up to 10 small patches) in 31, medium (up to 20 small patches) in 25, heavy (over 20 large patches) in 14 quarters, one quarter was almost completely infested, and in 20 others infestations were confined to woodland, farm yards and banks of ditches and creeks. In the suburban municipalities around Winnipeg one medium and one heavy infestation was found in addition to several isolated patches.

Poverty weed totalling 15 acres was found on four farms in the R.M. of Brenda. Intensive cultivation is holding the weed in check.

A survey was made in the Pilot Mound district without success to locate evidence of poisonous weeds.

THE PERSISTENT PERENNIAL WEED PROBLEM IN THE WESTERN CANADIAN PROVINCES.

T.V. Beck, Saskatchewan Dept. of Agriculture.

In discussing the problems involved in the control of any weed we must first understand the characteristics and growth habits of the weed itself. The persistent perennial weeds which are proving particularly troublesome in the Western Canadian provinces, especially the three prairie provinces are, leafy spurge, toadflax, hoary cress, field bindweed, Russian knapweed and bladder campion. Each of the weeds possesses some or all of the following characteristics which contribute to the difficulty of its control.

1. The root system is deep and possesses both lateral and vertical roots which penetrate well below the zone of tillage.
2. The roots are covered with a corky epidermis which resists decay.
3. They spread by seeds, by roots, or both.
4. They grow in thick patches and exclude almost all other vegetation.
5. Abundant root reserves allow the plants to resist at least one year of intensive tillage.

The extent of the problem can be best discussed in terms of acreages involved.

The Chart 3, Page 26, gives the approximate known acreages of persistent perennials by provinces.

Leafy spurge is rated as the most serious persistent perennial in Manitoba, with field bindweed rated as second and bladder campion third. In Saskatchewan toadflax is rated as the most serious problem, particularly in terms of its rapid spread. Leafy spurge is rated second, followed by hoary cress and Russian knapweed. Alberta rates the weeds the same as Saskatchewan with very little Russian knapweed, field bindweed or bladder campion present. British Columbia rates toadflax most serious and expresses concern over its rate of spread. It is followed by field bindweed, hoary cress, leafy spurge, bladder campion and Russian knapweed in that order. Generally speaking, the heaviest infestations of each are fairly concentrated but small patches are found scattered here and there throughout the entire area.

All of these weeds have been introduced to the area and have been gradually spread by various agencies to the point where they pose many difficult problems. The problems arise firstly from the failure of farmers to recognize the persistent perennials as such until they have spread to large acreages. This may be due to a lack of interest on the part of the farmer or to the belief that he can control them by regular cultural practices. It may also be due to the fact that they first occur in small patches which do not appear serious.

The weeds have been introduced in grain, fodder and grass seed. In Saskatchewan a great number of the infestations of leafy spurge can be traced to brome grass seed which is reported to have come from Manitoba. Many hoary cress and Russian knapweed infestations can be traced to importations of Turkestan alfalfa in early years. There has been, and still is, a laxity in particular districts with respect to the introduction and movement of weed infested seed and fodder. The movement of threshing equipment and other farm machinery over long distances tends to aggravate the situation, particularly where the weeds are spread by seed, and proper precautions in cleaning machinery are not taken.

Farmers are prone to attribute the spread to natural agencies, such as wind, animals, birds and water but do not seem to realize that by preventing the plants from setting seed by any means, be it mowing, hoeing or spraying, the spread of seed is impossible. It seems obvious then that the first major problem in the control of the persistent perennial weeds involves regulatory and extension work.

In regulatory work we have the problem of enforcement of adequate control measures. In the three prairie provinces local governments have the power to take control of lands infested with persistent perennials for purposes of eradication. However, municipalities are reluctant to do so because of the added responsibilities involved and the danger of creating ill feelings with friends and neighbours. However, Manitoba and Alberta have handled large acreages of land by this method. In Manitoba more than thirty properties totalling about 4,000 acres have been operated by municipalities. In Alberta 60 properties have been handled to date. Results have been very satisfactory. Most of the properties have been freed of persistent perennials and the crops grown on them have paid expenses. The publicity arising from the action and the use of the project for demonstration purposes have been valuable secondary benefits.

The enforcement of weed control legislation lies with the local weed inspector in all of the western provinces. Where considerable technical knowledge, time and understanding are required as in the case of the persistent perennial weeds, the local weed inspector is not always satisfactory. In many instances it has been found that special supervision is necessary if satisfactory results are to be obtained. Alberta provides one full time supervisor in each municipal district in addition to its regular inspectors. The Field Crops Branch also has four men working during the summer months with the municipal district supervisors. With this setup the province experiences no difficulty in obtaining necessary supervision.

Saskatchewan has only one supervisor working full time during the summer months and two part time men. These three men are all confined to the heavily infested toadflax area in the north-western part of the province. In addition, a short course for municipal weed inspectors, municipal officials and spray operators is being provided yearly with a view to training men who are better equipped to undertake supervision of local problems. Manitoba and British Columbia report no special supervision.

In extension work the problem is to familiarize the farmers with the identification, recommended control measures, persistent nature and special characteristics of the weeds. Farmers must be able to recognize the weed so that new infestations may be checked before they spread. They must understand that ordinary farm practices are not sufficient to eradicate or control them and that special methods are necessary. Difficulty is often encountered in obtaining control of these weeds on publically owned lands. Crown lands, forest reserves, railway right-of-ways, public roads and highways, towns and cities as well as Indian reserves have all proven to be sources of trouble. Special extension is needed to stimulate the necessary legislation and co-operation if satisfactory control is to be obtained. In addition, taxpayers in general must be acquainted with the special nature and characteristics of persistent weeds so that they realize the justification for

spending public funds on their control.

The second important problem involves soils. It does not appear that any of these weeds are confined to specific soil types. Where they are found on heavier soils, eradication is easier from both soil and economic standpoints. However, where they are found on lighter soils, in large infestations, the difficulty becomes greater. In many instances the land involved will not stand intensive tillage for physical or economic reasons. Though the problem may be due largely to past or present misuse of land it still must be solved or the area will remain unproductive and an ever-present menace to surrounding areas. Manitoba reports approximately 2000 acres abandoned to leafy spurge in the past, much of which has been reclaimed in recent years. However, when weed control measures make the cost of production too high abandonment is an everpresent threat and does not provide a solution to the problem.

Another problem is the cost, and sometimes, inadequacy of present control measures. Chemical control is mainly obtained through soil sterility. Regardless of the chemical used, control is costly and the soil is left unproductive for varying lengths of time. Furthermore, there appears to be a wide variation in the action of the chemicals under differing soil,moisture and climatic conditions. There also appears to be a difference in the persistence of the weeds under different conditions. These problems all indicate the necessity of better and cheaper chemicals, and of more experimental work on chemical control, cultural control and life history studies.

Lastly but of considerable importance is the financial problem. This is handled by different methods in each of the provinces. It is generally conceded that some financial assistance to local governments in controlling persistent perennials is necessary.

In Saskatchewan it has been the policy to assist municipalities by reimbursing them up to fifty percent of the cost of eradication programs. This assistance is given for chemicals, labour, grass seed, high pressure sprayers, cultivation under special agreements and special supervision. Under this policy an expenditure of approximately $65,000 has been made by the department in the past two years and all evidence indicates equal or greater expenditures for a few years yet.

Manitoba has formed weed units throughout the province each consisting of two to eight municipalities. Sixteen of these are now operating with good success. Approximately half the cost of the chemical used in controlling persistent perennials is absorbed by the government. This assistance is distributed through the weed control units and subsequently to the municipalities. The system has proven both acceptable and satisfactory. Approximate expenditures by the department in the past two years was $45,000.

In Alberta, special assistance is being given by the department in only one municipal district where toadflax is a particular problem. However, grants are made to Agricultural Service Boards for special projects and the department pays fifty percent of the cost of a full time supervisor. Cost to the government for <u>all</u> weed control in the past two years has been about $315,000.

British Columbia, having only slight acreages, has no form of assistance but has supplied farmers with chemical to be applied on an experimental basis.

In summary it may be stated that the persistent perennial weeds constitute a real menace to agriculture in many districts of Western Canada. Present control methods are costly and not too adequate. Each province has its own particular methods of dealing with the regulatory and financial difficulties involved. Those provinces with large infestations have realized that the problem has become one for provincial and local governments as well as individual farmers. To cope with the situation adequately a concerted and co-operative effort on the part of all three is essential.

CHEMICAL CONTROL OF PERSISTENT PERENNIAL WEEDS IN WESTERN CANADA.

W.G. Corns, University of Alberta.

Owing to the great scope of the subject, I shall deal rather generally with two phases of the topic your program committee had in mind, namely: (a) experimental work and (b) control programs. At the outset I am quick to acknowledge the valuable assistance received from everyone concerned with chemical weed control in the various provinces. A number of abstracts have been received and are appended to this report.

First, with reference to experimental work, it is well known that soil sterilants have a long history of testing for effects on patches of persistent perennials such as leafy spurge, hoary cress, field bindweed, Russian knapweed and latterly toad flax. Out of the earlier work, more than 25 years ago, sodium chlorate emerged as probably the most useful despite its disadvantages of flammability etc.

Much more recently, the sweeping success of 2,4-D against certain annual weeds in grain crops also attracted attention toward use of this and similar chemicals on persistent perennials both in and out of grain fields. At the same time, such experimentation seemed to be a stimulus for renewed interest in, and popularization of, research with soil sterilants old and new, and with combinations of various herbicides. This over-all trend has not been peculiar to Western Canada but has been evident nearly everywhere with obviously good results. In this work, the commercial chemical companies have played an extremely important part by development of the numerous products continually being offered for our assessment.

Sodium chlorate and its various commercial formulations have been joined, but have not been replaced, by other chlorate compounds and borax formulations with advantages for certain weed problems. Likewise, TCA and CMU have, fairly recently, appeared on the scene. I think that this completes the group of chemicals of major importance to our discussion now.

There are a number of others that might be noted but they are either poorly understood or seem to be of limited potential value for our problem at this time.

How have these various chemicals been shown to fit into the picture in western Canada? Leafy spurge is an appropriate weed to take as an example. Soil sterilization by chlorate at about 2 lb. per 100 sq. feet has in general, proved very satisfactory for eradication of small patches, particularly in Manitoba, where establishment of many major infestations has been prevented in this way. Polybor chlorate, Chlorax and borax compounds are beginning to compete with sodium chlorate partly owing to their non-fire-hazardous nature. In several instances,

they have been shown to be at least the equal of sodium chlorate against deep rooted perennials but in general they are probably less reliable than sodium chlorate against perennial grasses. It is, of course, impractical to sterilize the soil over large areas, so apart from cultural methods to be dealt with by another speaker, there has been resort to application of 2,4-D or allied substances in such situations.

Like all the other bad perennials, leafy spurge cannot be eradicated by a single treatment with 2,4-D although such treatments have an immediate useful effect in checking spurge growth in grain crops. Where long range programs are anticipated, the problem is to decide on technique and merits of repeated treatments. This question is extremely interesting and seems to be one of greatest importance in our thinking concerning systematic weed control programs. I think that a number of us who have until recently, tended to under-rate the importance of 2,4-D as a means of eradication of leafy spurge, hoary cress and toad flax, now have reason to change our minds to some extent. It is true that apparent failures from one or two years' application have been quite numerous but we are now getting some information covering experimental programs extending over a longer period of time. Specifically, there are reports of positive results from repeated annual or twice-yearly applications of 2,4-D to leafy spurge in Manitoba and Alberta, to hoary cress in Manitoba, Alberta and British Columbia, and to toad flax in Saskatchewan and Alberta. Results from use of 2,4-D on leafy spurge in certain parts of B.C. and Manitoba have been less satisfactory, but on the whole the outlook is bright. This opinion is based on information supplied by Mr. Brown from Brandon Experimental Farm by Mr. Wood and Mr. Craig, of Manitoba Weed Commission, by Mr. Friesen in Saskatchewan, by Mr. Sterling, Mr. Carder and myself in Alberta, by Mr. Putnam in B.C.

It seems apparent that best results have been obtained where deep rooted perennial weed were treated in grassland undisturbed by cultivation or where a grass like crested wheat or brome was sown as a competive crop. This may be the best method for municipal officials and other attacking for example, miles of rough roadside infested with toad flax in Alberta. Soil sterilants like sodium chlorate and CMU even under optimum conditions cost anywhere from $150 - $200 per acre. An application of a pound of 2,4-D per acre costs less than $2 so at this rate one could, theoretically, afford to spray twice a year for about 50 years with 2,4-D and still break even. And in addition, the retention of grass cover would be an advantage on roadsides. Moreover, the indications are that a period of no more than 4 or 5 years' spraying with 2,4-D might be adequate, and experience may show, as it has in some other countries, that MCP should have a place in such programs, particularly for hoary cress control.

The undesirable grasses remain for condideration. This leads us to make further comments about CMU, one of the newer chemicals effective against persistent perennial grasses as well as against other species already considered. Nearly all the workers who have tried CMU in western Canada agree that it is a top ranking soil-sterilant. Effective rates for this purpose range from 40 to 80 lb. or more per acre making its cost at present, comparable to that of the other soil sterilants. In general, it is safe to say that CMU although slow in action, is appreciably better than sodium chlorate as a grass killer, and sodium chlorate is not bad. Moreover, CMU is showing up very well against toad flax in Saskatchewan and Alberta. It has been effective against field bindweed at Morden Manitoba. At some stations dandelion, Canada thistle, leafy spurge and sow thistle have been slow to go, or have persisted in crippled form through a second year after application of CMU. Certainly however, this chemical seems to be definitely establishing itself among our assortment of chemicals ready for prescriptions of one kind or another.

To conclude this discussion on experimental work, I shall deal briefly with TCA. This chemical has been well-assessed during the past few years.Its main reputation is, of course, as a couch grass herbicide at rates ranging from 40 to 100 lb. or more per acre depending upon envirnonmental and soil conditions. It is relatively ineffective against broadleaved perennials. The effectiveness of TCA as a grass-killer is enhanced by cultivation prior to chemical treatment. It is interesting to note here that the efficiency of CMU, in contrast with TCA, does not seem to be improved by such tillage. In general, it is better to apply TCA in fall than in spring. This is perhaps associated with the beneficial effect of winter precipitation. The residual effect of TCA although much shorter than that of chlorate or of CMU, sometimes persists into the second year following a spring application and usually is apparent in the spring following a fall application. Commercial use of TCA in western Canada has been established but so far, owing to cost, has been almost completely confined to lawn and garden land in urban centres.

Before I close, I should say something more than has already been mentioned incidentally about organized control programs in western Canada. These include what has been done in a big way, and what is planned to be done, by those in charge of provincial weed control programs extending from the Department of Agriculture through to the municipalities and farms. Since chemical weed control came to the fore, our provincial authorities, fortunately, have not left everything having to do with field-testing of herbicides to the experimental farms and universities. While their primary duties are administrative, the government supervisors have found time to do original field-testing as well as to follow up the suggestions arising from the manufacturer and the research stations.

In Manitoba, one of the outstanding programs has been concerned with efforts to eradicate leafy spurge. As far back as 1937 when the prevalence of this weed had become alarming, the Brandon experimental farm several mortgage and elevator companies, the provincial government and the municipalities co-operated to use chemicals to eradicate the small patches of spurge and to use cultural methods for the larger acreages. In 1940-41 the Manitoba Weeds Commission organized 12 weed control units, later increased to 17, each comprised of 3 to 6 municipalities which purchased high pressure sprayers for application of Atlacide to small and scattered patches of leafy spurge. During the past 12 years they have used a total of more than 3 million pounds of Atlacide. Each year until 1951, the necessary amounts increased but now there are signs that the peak has been reached and requirements should decline. About 400,000 lb. of Atlacide were used in Manitoba in 1951. The costs for chemical have been borne on a 50-50 basis between the Department of Agriculture and the municipalities.

Other speakers will deal with the cultural methods used in the campaign and with application of regulatory legislation where necessary.

It is noteworthy that Mr. Wood and Mr. Craig have used soil sterilants in preference to 2,4-D for treatment of patches of leafy spurge. They have, however, used 2,4-D in combination with grass competition for control of spurge on sub-marginal sandy soils.

From Saskatchewan too, we hear of satisfying results. Mr. Beck of the provincial Department of Agriculture reports that Atlacide has been the only chemical used extensively on persistent perennial weeds. This chemical is supplied to the municipalities at cost. Fifty percent of the cost of the Atlacide and of the labor involved is then refunded to the municipality by the Department on completion of the work. This year the Saskatchewan government purchased about 600,000 pounds of Atlacide for their perennial weed campaign.

In Alberta, the Agricultural Service Boards are an important feature of the organization for weed control and other agricultural matters. There are thirty-five such service boards in Alberta, some employing additional men as weed inspectors on a seasonal basis.

In the main so far as persistent perennials are concerned, it is again a story of the use of sodium chlorate to the extent of about 300,000 lbs. per year obtained in bulk by the government for sale to the municipalities. Throughout Alberta, chlorate has for the most part a good record in the campaign with leafy spurge, hoary cress, field bindweed, Russian knapweed and toad flax. Chlorate, however, appears to fall down in its efficiency on alkaline soils. It remains to be seen whether newer soil sterilants such as polybor chlorate and CMU which have already given favorable results in experimental trials in western Canada will replace sodium chlorate in at least some situations.

Similar results with sterilants have been reported by Mr. Putnam for B.C. but in his rugged province there seems to be, as one might expect, somewhat less consistency in behavior of treated weeds. Again, in all provinces, it appears to be important to note apart from some exceptions already mentioned, the recent encouraging results from spraying with 2,4-D on hoary cress, leafy spurge, and toad flax especially where crested wheat or brome grass competition was available.

It seems that the hormone herbicides are beginning to merit more honorable mention in this field and likewise the newer soil sterilants can be expected to find their way into potentially valuable modifications of the existing excellent control programs. As long as we have the interest, aggressiveness, and co-operation now everywhere apparent in connection with weed control research, extension, and administration in western Canada, we have every reason to believe that the voluntary activity of men on the land will be with us to accomplish what needs to be done.

CULTURAL AND OTHER CONTROL METHODS OF PERSISTENT PERENNIAL WEEDS.

H.A. Craig, Manitoba Department of Agriculture.

The deep-rooted and persistent group of perennial weeds as the term implies, have in common a very extensive and deep root system that permits them to store within this system large reserves of food. As a result of this the plant becomes pretty much independent of surface conditions. This explains why ordinary good summerfallowing or other tillage carried out throughout a season has little or no effect upon weeds coming within this classification. Within recent years research and practical field work, in both the United States and Canada, has demonstrated that anyone of the several weeds species that comprise the group of persistent perennials can be eradicated by tillage or by combination of intensive cultivation alternated with cropping.

Methods of control of persistent perennial weeds vary with the extent of the infestations, as well as the type and nature of the soil in which they are found. Work conducted by the Manitoba Weeds Commission over the last ten years indicate four lines of approach as proving satisfactory. These are:

(1) Chemical - for small and scattered patches.

(2) Intensive cultivation - for numerous patches or extensive infestations on arable land.

(3) Grazing with sheep - for numerous patches or extensive infestations on land unsuited to intensive cultivation.

(4) Keep out of cultivation - the very poor light-textured soils heavily infested.

Two methods of cultural control are advocated:

(1) Land that will permit intensive working is cultivated over a two-year period before being cropped.

(2) The land may be alternately cultivated and cropped over the five-year period. The latter method, especially if cultivation is started immediately after the removal of the crop, is gaining in favor for at least two reasons:

(a) The hazard of soil erosion is lessened.

(b) The handling of a very rank crop that may follow two or more years of continuous cultivation is overcome.

Success of the cultivation program is based on three essentials:

(1) Cultivation must be extended over a sufficient length of time to completely starve out the weed's root-system.

(2) Cultivation must be carried out at regular intervals, usually about every two weeks, from early spring until freeze-up. Plants must not at any time be allowed to appear above ground for more than four or five days, thereby preventing them from storing additional plant food in the root systems. The interval between cultivations will be somewhat longer the second year, due to the weakened condition of the plants.

(3) A thorough job of cultivation must be done each time. This will necessitate a careful operator, ample power and a cultivator in good condition, equipped with sharp shovels that have plenty of overlap.

Two years of intensive cultivation will not always completely eradicate these weeds with the result that stray plants may appear in the growing crop. Treating the crop with 2,4-D at the maximum recommended rates, for the variety of grain and stage of growth, not only prevents weed seeds ripening but inhibits the growth of the weeds. Both the 2,4-D treatment and early fall cultivations are important links in the eradication of persistent perennials.

The eradication of infestations of the deep-rooted perennials on light sandy or stony soils presents a problem of a more baffling nature. The hazard of soil drifting, the cost of eradication in relation to the value of the land, and other factors, usually rule out intensive cultivation as a means of eradication. Where leafy spurge is the weed under consideration, sheep offer the best and cheapest method of control. Although sheep when first introduced to the weed sometimes show a dislike for it, pasturing early in the season when the leafy spurge plants are young and tender overcomes the difficulty: they soon come to prefer spurge to grass or other herbage. An important factor in the success of this method of eradication is having a sufficient number of sheep confined to the infestation to insure the weed being continuously close-cropped. The program, like intensive cultivation, must extend over a sufficient number of years to completely starve out the plant's roots.

Seeds of any of these weed species may remain in the ground for a number of years in a viable condition to later germinate. Although such seedlings are not difficult to kill, it is advisable to continue systematic tillage, after the eradication program is completed, so that they do not have the opportunity to become established.

In Manitoba a forward step in the control of persistent perennial weeds was taken when an amendment to the Noxious Weeds Act was enacted by the legislature in 1942. This gave to municipalities the authority to take over, under lease for a period of five years, properties declared "weed infested" and to undertake a program of intensive cultivation alternated with cropping, as a means of eradicating the offending weeds. The municipality either purchases its own equipment and hires an operator, or has the work done under contract. Since 1943, 12 properties totalling 1,547, acres, have been returned to the owners freed of weeds. With each of these properties the municipality was able to return a surplus, over the cost of eradication, to the owner. Equally as important as the eradication of the leafy spurge menace was the general improvement of the land itself. Prior to intensive cultivation buyers could not be secured when this land was offered for sale at as low a figure as five dollars an acre, but at the completion of the eradication program the land was readily sold at prevailing land prices.

Where large infestations are encountered on very light sandy soil likely to blow if cultivated or pastured, it may be in the best interests of all concerned to quarantine the land, and police the margins of the area to prevent the further spread of the problem weed.

WEED SCREENINGS AND THEIR DISPOSAL

H.J. Mather, Line Elevators Farm Service.

The principal grain growing area of Western Canada comprises the souther portions of the Prairie Provinces of Manitoba, Saskatchewan and Alberta. In this area more than 40 million acres are planted to wheat, oats, barley, rye and flax annually.

The total volume of the above crops varies considerably from year to year -- as does the volume of screenings removed from these grains. Because of this variation the figures used in this paper are based on the average of the 1950 and 1951 crops, as the average production of grains for these years, and the recovery of screenings, approximates the long-time average.

The average amount of grain marketed during the crop years 1950 and 1951 was 770 million bushels. The total dockage removed averaged roughly 2½%. This totals 333,500 tons per year, or 200 trainloads of 55 cars each. The freight cost of transporting this material would be well over one million dollars.

The presence of such a large quantity of undesirable material increases tremendously the cost of harvesting and handling the Prairie grain crop. Not only are shipping costs increased, but the grain must be cleaned at some stage of its handling, adding again to the over-all cost of marketing the crop.

In Western Canada, the approach to the screenings problem varies from province to province. Alberta, for instance, has rather strict legislation regarding the handling of screenings. It is necessary to secure a permit to purchase screenings. Anyone selling screenings must do so only to a person having a permit and must forward a record of all sales to the Alberta Department of Agriculture. Persons feeding screenings have their premises inspected by a duly appointed weed inspector who must be satisfied that due care is being exercised in handling the screenings. In Alberta, screenings must be transported only in a covered wagon or truck box, or in containers which will not allow weed seeds to escape. Operators of cleaning plants, mills, elevators and others having screenings under their control must keep them in proper storage or destroy them by burning.

In Saskatchewan a permit from a weed inspector or municipal clerk is required before screenings may be moved from elevators or mills. Within five days after threshing, screenings containing weed seeds must be properly stored or destroyed.

In Manitoba, the stress is toward education rather than regulation. In this province, a weed inspector may prohibit placing screenings in any place where they might become a menace.

Roughly 2% of the grain marketed in Western Canada is cleaned at local country elevators. The percentage cleaned is considerably higher in Manitoba than in Saskatchewan and Alberta. The total screenings removed at local elevators from the crops of 1950 and 1951 averaged 48,055 tons per year, of which 63% was taken home by farmers.

A recent survey made in Manitoba showed that in most cases this material was hauled in open wagons and trucks. Where possible, the screenings not taken home by farmers are sold to local feed lots. Screenings not sold locally are sold in bulk carload lots to any available market.

The modern method of transporting weed screenings in fast moving trucks, which are seldom covered and often leaking, presents a serious weed seed dispersal problem. To reduce this menace, provincial government weed officials have continually urged farmers and truckers, when hauling screenings to use leak-proof grain boxes and to cover their loads with a tarpaulin, especially on windy days. Obviously movement of screenings locally can be, and unfortunately is, a very important source of weed dissemination in Western Canada.

The Manitoba survey further revealed that screenings originating from threshers or combines were disposed of as follows: fed, 70%; burned, 15%; sold, 10%; left on ground, 5%. When sold, about 20% was handled by commercial truckers.

By far the larger part, about 98% of the

screenings originating from each year's crop in Western Canada, is not removed from the grain until it arrives at Interior, Lakehead or Pacific terminals.

The value of this material and the disposal of it depends very largely upon the price and quantity of feed grains available. When feed grains are plentiful and cheap the prices offered for screenings are low and vice versa. When the price offered for screenings is low most of them are disposed of as fuel.

It should be pointed out here that many problems are involved in the disposal of screenings from terminal elevators. Due to the variable quality of screenings and the erratic nature of demand, terminal elevators have, of necessity, been compelled to invest in very expensive processing machinery so as to make as large a percentage as possible of this by-product into a saleable and useful commodity. Even under the best of conditions, however, the finished products from screenings have a very erratic and uncertain market value. As a matter of fact, in certain years, the disposal of refuse screenings on any basis presents a most difficult problem for terminal operators. The residue from Refuse Screenings that remain at terminal elevators have always presented a troublesome disposal problem.

Screenings in Canada are sold under a grade system established by the Canada Department of Agriculture. A brief description of these grades and their use follows:

No. 1 Feed Screenings. This grade carries not more than 7% crude fibre, and a limited amount of weed seeds. It is used in commercial feed mixtures or as a whole or ground feed.

No. 2 Feed Screenings. Similar in quality to No.1. They are often a mixture of No. 1 and Mixed Feed Oats and are used the same as No. 1 Feed Screenings.

Mixed Feed Oats. Mostly Wild Oats removed from wheat with disc cleaner equipment. They are used ground, or fed whole -- similar to oats.

Uncleaned Screenings. These are straight elevators cleanings. They usually contain too many weed seeds to qualify for the preceding grades and contain from 4% to 50% wheat straw and weed seeds. They are used mostly as roughage feeds.

Refuse Screenings. These are the final siftings from commercial grain. They may contain straw, chaff, dust and dirt, as well as large and small weed seeds. They are almost useless as feed. When prices are low they are used as fuel.

Miscellaneous Screenings. This grade includes refuse flax, mustard seed, refuse rape and other oil seeds. They must be used either for feed or for their oil content. Ergot mix also falls into this grade, the most of which is cleaned and refined for medicinal purposes.

All grades of screenings except "Uncleaned" and "Refuse" screenings are cleaned before shipping from the terminals. Uncleaned and Refuse screenings are processed only to extract oil seeds if these are present in large quantities.

According to statistics provided by the Plant Products Division, Canada Department of Agriculture, an average of 333,500 tons of screenings of originated annually at the various terminals during the crop years 1949-50 and 1950-51. Of this amount, 108,500 tons were shipped to 9 Canadian provinces, while the remainder were exported to the United States and other countries.

It is reported that, in 1947, some 12,000 tons of Wild Mustard and other oil seeds were removed from the Western crop at the terminals. With the advent and widespread farmer use of 2,4-D very much smaller quantities than this have been removed in recent years. In spite of this reduction in small seeds, however, the total volume of screenings removed from the Western grain crop each year remains about the same. As might be expected, while the volume of small seeds has been reduced in recent years, the volume of Wild Oats has increased.

Viability of Weed Seeds in Screenings. Over the years, considerable attention has been given to the problem of destroying the viability of weed seeds in screenings. So far, no completely satisfactory method has been devised. Grinding, and to a lesser degree cooking, are the common methods still in use. However, the introduction of the hammer mill has reduced appreciably the hazard of using weed seed as feed for livestock as it insures a fine grinding of the screenings. Without doubt, a cheap, efficient method of devitalizing weed seeds would go a long way toward helping to solve one of the major problems associated with the handling and marketing of weed screenings.

In this connection it might be interesting to present the results of recent investigations made by Dr. A.J. Wood of the University of British Columbia. Dr. Wood reports that he and his associates have been investigating the possibility of increasing the value of refuse screenings for livestock feed by the addition of whale solubles.

These workers have already reported (See Proceedings of the Fifth Western Canadian Weed Control Conference, Vancouver, 1951) that the chemical analyses of representative samples of refuse screenings show that they have a feeding value approximating that of oats. Screenings are, however, somewhat higher in fibre and ash content.

By adding fish solubles, which have a high protein content, to refuse screenings, these workers have found that it is possible to raise the moisture content of screenings to about 35%. This mixture, after heating at 200°F., for a short period, can then be pressed into pellet form. Germination tests on this material revealed that devitalization of weed seeds had been achieved.

Dr. Wood reports that a considerable quantity of these screening pellets have been manufactured so far, the most of which have been used in large-scale livestock feeding experiments. In these tests it was found that 6 pounds of pellets plus two pounds of hay produced a one pound gain. In one extensive feeding test, the average gain was 2.6 pounds per day. It is reported that the carcass quality of animals so fed is completely satisfactory.

This is indeed an interesting and promising new approach to the problem of refuse screenings utilization. Further experimental data must be accumulated before all aspects of this method have been satisfactorily solved. However, it is a part of the ever-changing picture. Other interesting developments leading to the complete devitalization of weed seeds present in weed screenings may follow.

THE OCCURRENCE AND THE PROBLEM OF WILD OATS IN THE WEED CONFERENCE AREA.

H.E. Wood, Manitoba Department of Agriculture.

The Wild Oat, Avena fatua, is the most widespread and troublesome of the numberous species of established noxious weeds. This applies to almost the entire cultivated portion of the Northern Plains of the Great Plains Region of North America. This weed is responsible for tremendous losses to farmers chiefly through:

1. Added expense of tillage and other farm operations.
2. Reduction of yield and quality of grain.
3. Added handling, elevator, freight, and other costs.

An annual weed, introduced rather than native, wild oats came into this area well in advance of the turn of the Century when pioneer settlements were becoming established. Sufficient evidence is available to indicate that wild oats were probably introduced as admixtures of seed and feed. Settlers of that day did not know the hazard the weed presented; moreover they were without adequate means of removing the seed of this weed from other seed, especially that of cereals.

For much of the data contained herein, the writer is indebted to State and Provincial Weed Supervisors in the Conference area who were most helpful in completing and returning a Questionnaire on wild oats, descriptive of the problem in their area.

In the Northern Plains region wild oats can be said to be a weed associated with extensive small grain farming. Where row crops and rotations that include hay and pasture crops are the rule, the weed is of little or no consequence. According to Willard of Ohio, "Wild oats are essentially unknown in Ohio, due to regular rotating, including corn and forage crops." Sylwester of Iowa reports as follows: "Our rotation system, whereby small grain lands are in clover or alfalfa which are being mowed repeatedly and the land returned to corn and soybeans, keeps wild oats under control. In the last twenty years I have never actually seen wild oats in Iowa".

Wild oats rate as by far the most troublesome weed in a very large and compact block comprising the north half of South Dakota, the northwest fringe of Minnesota, much of North Dakota, Montana, and most of the three Prairie Provinces - Manitoba, Saskatchewan and Alberta. Elsewhere within the Conference area, if not totally absent, their occurrence is scattered and of decidedly minor importance. Within the infested block some 106 million acres are under cultivation. Of this total it is estimated that 61 million acres carry wild oats infestations; 29 million acres of which can be rated as very severe, and presenting a major weed control problem.

While occurring over a very wide range of soil, climatic,and other conditions, wild oats are inclined to be "choosey" as to invironment. Their preference seems to be for cool, moist soil conditions. This may be observed in at least two ways. First, seldom are wild oats a serious weed in the more arid and hot sections of the Northern Plains, except where moisture becomes available through irrigation. Second, wild oats are usually more abundant on the lower, damper parts of a field, especially in water runs, than they are on the knolls or southern exposures. In general, the plant seems to prefer the heavy clay soils and those of the parkland areas, rather than the drier and more arid sections.

Farmers are faced with a most difficult and complex problem in controlling wild oats. Nature has abundantly endowed the plant with characteristics to ensure its perpetuation. Most farmers find it hazardous and costly to radically change their system of farming to properly control this weed. Among the many endowed characteristics of wild oats are:

1. Early maturity and shedding of seeds before the grain crop ripens.
2. Seed dormancy and the necessity of "after ripening" before seed will germinate.
3. Low temperature requirements, which restrict the period in which seeds will germinate.
4. Viability of seed buried in the soil for long periods.

Changing from extensive mechanized grain farming, so generally the practice over the area in which wild oats are troublesome, to other systems of farming would be difficult and risky for many reasons, to mention only three:

1. Soil and climate favor extensive grain growing, rather than an intensive agriculture.
2. Mechanization and extensive farming, which are complementary to each other, are a logical development of the area, and are peculiarly adapted to it.
3. Row and fodder crops are of uncertain outcome and their profitable disposition is oftentimes a problem.

In concluding this rather general paper on the occurrence of wild oats, and of the problems associated with them, I wish to close on a note of optimism. Since the advent of 2,4-D, which is bringing under control most of the broad-leaved weed species, the wild oat problem has been pushed to the front, as it were. Farmers at long last have become much more wild oat conscious. Already in Manitoba, for instance, there are noticeable and promising indications that a move is now under way to beat this age-old weed. With the contributions present-day weed scientists are making, I feel we can be most hopeful of ultimate success in controlling wild oats.

TAXONOMIC INVESTIGATIONS ON WILD OATS.

D.R. Lindsay, Science Service, Ottawa.

Introduction

Mr. Wood has just given you an account of the widespread occurrence of wild oats and of the problems presented by this plant in the Weed Conference area. So far as western Canada is concerned, all of you will agree that wild oats is the number one weed infesting cereal crops. Each year is marked by enormous losses from this weed both to the farmer

and to the country as a whole. The magnitude of the loss due to wild oats can be estimated from a report of the Beaverlodge Experimental Station this year. One field of wheat in this area gave an average yield of approximately 4 bushels of wheat and 39 bushels of wild oats per acre. According to Batho, the average annual loss in Manitoba due to wild oats runs into "very many thousands, probably into a few millions, of dollars." Leggett has also pointed out that in western Canadian grain shipments at least one third of the dockage is wild oats.

The wild oat problem, then, is one which warrants intensive study not only from the control standpoint but also from the biological side. An investigation of wild oats may conveniently be resolved into three phases: taxonomic, cytogenetic and physiological. Establishing the correct identity of wild oats as they occur in Canada is an obvious preliminary step to tackling the cytogenetic and physiological phases.For this reason,the work so far has been largely confined to a taxonomic study of the wild oat population of the Prairie Provinces. This report will deal with the first year's investigations on this phase and should be regarded as definitely exploratory.

For the taxonomic work, the author has largely followed the classification of Malzew. This worker has divided the A. fatua group into a number of subspecies: ssp. fatua, cultiformis, septentrionalis and meridionalis. Each of these subspecies has distinctive morphological characters by which they can be readily separated and each subspecies can be further divided into four principal varieties by certain grain characteristics.

Methods.

During 1951 mass collections of wild oats were made by personnel of five Experimental Stations in western Canada: Beaverlodge and Lacombe, Alta.; Melfort and Indian Head, Sask.; and Brandon, Man. These specimens were collected at random from fields in the vicinity of each station. About 450 dried plants were forwarded to the author for study.

Growing tests were also carried out in 1952 in plots of the Division of Botany and Plant Pathology. Grains were selected from various plants of the western Canada collection and grown on to maturity. Collections of mature plants were made late in summer and later examined.

This year eight Experimental Stations in the Prairie Provinces participated in an exchange of wild oat seed from their respective localities. These samples were grown in plots. During the summer, the author examined these plants and collected material which, as yet, has only been examined superficially. In addition, infested fields in the vicinity of each station were also visited and specimens collected.

Results.

As far as could be established in the present study, all the wild oats in western Canada is Avena fatua. Species of wild oats, other than A. fatua, may eventually be found. Thurston has mentioned A ludoviciana infesting cereal crops in England, and Hitchcock's Manual lists A barbata as a weed on the Pacific Coast of the United States.

Most of the specimens examined fell into the A. fatua ssp. fatua group. A few, however, appeared to fit Malzew's description of ssp. cultiformis but these will be discussed later. The material under study contained all four varieties of ssp. fatua described by Malzew: pilosissima, glabrata, intermedia and vilis. Figure 1 shows the four grain types of these varieties. It will be seen that two grains at the left (vars. pilosissima and glabrata) have long hairs around the "suckermouth" while the two at the right have short hairs (vars. intermedia and vilis). Pilosissima can be separated from glabrata by its dense lemma pubescence. The glabrata variety is almost glabrous in most cases. In the same manner, intermedia can be separated from vilis.Colour, to some extent can also be used in the separation of these varieties. Both pilosissima and intermedia when mature have dark brown to blackish grains with reddish-brown hairs around the "suckermouth". The grain colour of glabrata and vilis is variable. One can find plants with all yellow grains and others with all dark gray or blackish grains. More commonly, both gray and yellow grains can be found on the same plant or, in some cases, grains have an intermediate yellow-gray colour which makes them difficult to classify. Hairs around the "suckermouth" are a whitish colour. The possible significance of colour will be discussed later.

It is interesting to note the status of these four varieties in the populations of the five Experemental Stations. These data are shown in Table 4 Page 26,

Although the above data may not be conclusive due to an inadequate sampling, nevertheless, there are some interesting trends. Var. glabrata is by far the least common of the wild oat types. There is also a tendency for one variety to predominate at some of the stations. For example, Lacombe shows a high percentage of intermedia while at Indian Head, pilosissima is the common variety. There was some indication from observations made this summer that some fields had a preponderance of one variety; in other fields close by, mixtures occurred. The significance of this is not yet known.

Growing tests carried out on these four types showed that the pilosissima and intermedia types bred virtually true to type. The second generation plants showed little variability and did not differ significantly from the parents from which the seed was originally selected. In the glabrata and vilis groups,however, some differences occurred. In one case, a glabrata type segregated into plants with both long and short hairs around the "suckermouth". Lemma pubescence of a few of the glabrata and vilis plants was variable. Although virtually glabrous grains were planted in these cases a few types emerged with some pubescence on the lemmas. Colour was even less fixed. Most of the second generation plants had yellow grains with some gray grains at the tip of the panicle or at the tips of panicle branches. The parent seed, however, was mostly gray in colour.

For the growing tests some seed was also selected from so-called "off type" plants. One or two plants of the western Canada collection had typical "fatua" grains which were plumper than in the majority of the specimens examined. When grown there were some striking differences in growth habit between these plants and the other four varieties. Instead of a prostrate or semi-erect growth these plants had upright culms and contracted panicles resembling cultivated oats. Mature grains again exhibited the "fatua" characters but were plump. Such plants fit Malzew's description of ssp. cultiformis which he claims to be present in Canada.

Discussion

From the results obtained I think we can be reasonably certain that most of the wild oats in western Canada falls into the A. fatua ssp. fatua group. Subspecies cultiformis may also be present but is likely localized and of sporadic occurrence as

Malzew has indicated for Europe. Its reputed lack of dormancy would make it difficult for this subspecies to survive the climatic conditions of the Prairies.

The preceeding data have also indicated that the wild oats of western Canada can be placed into four varieties of ssp. fatua. At least two of these varieties, pilosissima and intermedia, are rather uniform taxonomically and breed reasonably true to type. Glabrata and vilis, however, are less fixed and one can only theorize as to their origin. In artificial crosses carried out by Surface and Aamodt et al between wild oats of the "intermedia type" and cultivated oats many gray and yellow wild oat forms appeared in the F2 and succeeding generations. Some of these were shown to be homozygous for gray or yellow grain colour and others further segregated. into yellows and grays. In addition to inherited genes for colour, Philp believes the environment to have an effect in accentuating grain colour in wild oats. Variability of grain colour in the glabrata and vilis groups, then, is due to a number of factors. Cytogenetic studies should be very illuminating in the understanding of all four varieties.

Summary and Conclusions.

1. An examination of some 450 wild oat specimens from five Experimental Stations in western Canada has shown that most plants could be placed into the Avena fatua ssp. fatua group.

2. It was also possible to place these specimens into four varieties of ssp. fatua, viz. pilosissima, glabrata, intermedia and vilis.

3. Taxonomic study indicated that vars. pilosissima and intermedia were rather uniform morphologically but that the glabrata and vilis types were more variable in lemma pubescence and colour.

4. Growing tests showed that the pilosissima and intermedia varieties apparently undergo little segregation for the characters studied but that segregation occurred in a few of the glabrata and vilis groups. These tests also revealed that another ssp. of A. fatua viz. cultiformis may be present in western Canada.

5. The wild oat populations of the five Experimental Stations were broken down into varietal percentages which showed glabrata to be the rarest variety and that some varieties tended to predominate at some stations.

6. Discussion of the four wild oat varieties has indicated the need for more investigation on the cytology of the entities.

WILD OATS - CULTURAL CONTROL

D.A. Brown, Dominion Experimental Farm, Brandon

This weed is a companion crop particularly with spring seeded cereals and flax. Because of this there is the possibility so long as grain constitutes the only crop in a rotation then just so long will wild oats remain a constant, if not ever increasing, problem. Since grain farming is likely to be the preferred system over the Central Plains region of Canada and the northern U.S.A. for a long time to come, the challenge is to discover methods of subduing wild oats on land that is continuously devoted to grain crops. Following is an outline of methods that are giving the best results up to the present time.

A. TILLAGE METHODS.

(1) Delayed Seeding. It is the concensus of opinion among those engaged in weed research on the Experimental stations in Western Canada that delaying the seeding of grain in the spring until wild oats have grown and can be killed by tillage, is the most successful method of control in a grain rotation. At the Brandon Farm in 1952 barley seeded May 8 averaged 28.5 wild oats plants per sq. yd. compared with 4.4 plants in adjacent plots where the seeding was delayed until June 11. At Indian Head, Sask, the stand of wild oats was reduced from 24 per sq. yd. to a mere trace by deferred spring seeding. Late seeding, in Manitoba at least, usually results in lower yields and quality of grain. This important factor must therefore be weighed against the benefits of a reduced infestation of wild oats.

(2) Fall Tillage. This is beneficial mainly to cover the seed as a means of inducing it to grow the next spring.

(3) Pre-seeding Tillage.

(a) Stubble land cultivated or ploughed in autumn should be harrowed and packed early in the spring to encourage wild oat seed to germinate.

(b) Tillage immediately before drilling the crop is done to destroy wild oat plants. This is perhaps the most important tillage directed against the weed and should be done by implements that will assure a complete kill. The plants should be in the two-leaf stage before the tillage is done.

(4) Post Seeding Tillage. If conditions are favourable this can be made an effective method of controlling wild oats in crops of cereals. Grain should be seeded two inches deep and just as the cotyledon is nearing the surface tillage should be done preferably with a rod or wire weeder. On a level surface the wide-level discer may do a satisfactory job.

(5) Summer-fallow. Increasing dependence is being placed on summer-fallowing as a means of fighting weeds in Prairie Canada. When carefully managed a summerfallow will "grow out" less or more wild oats, but in most instances sufficient seed remains to produce a re-seeding of the surface soil and cause pollution of the second grain crop unless the most careful preventive tillage measures are taken. Summer-fallow does, however, assure the grain farmer of the North Central Great Plains the heaviest possible yield of grain with a measure of freedom from wild oats.

B. Cropping Systems.

(1) Seeding to grass and legumes. Since wild oats is companion to annual grain crops it is reasonable to assume that retiring land from grain at intervals of several years and for periods of several years will eradicate wild oats. Grassing down land infested with wild oats seed has, however, not brought the expected relief to many farmers. Obviously, due to the large quantity of wild oats seed in the surface soil, and, because much of this seed lies dormant for several years the first seeding down even if left five years may give disappointing results. Grass will help to control wild oats but it has to be repeated at regular intervals. Ample evidence that grassing down is the best permanent remedy is obtained from farms in areas of the country where grass farming is followed. A seed grower in Swan River Valley in the heart of

the worst wild oats infested area in Manitoba is able every year to hand pick the wild oats plants in his crop, place them in a sack and bring them to the yard to be destroyed. Why? Because for thirty years he has followed a rotation that has kept half his land in grass and legumes for hay, pasture and seed production. At the Brandon Experimental Farm two crop rotations were started thirty years ago on an area evenly infested with wild oats. One is a four-year grain rotation of fallow, wheat, wheat, oats. The other is a six-year rotation having two years of mixed grass-legume hay between the two crops of wheat. During the last five years threshed grain on the four-year rotation has had a wild oats content by weight of 1.8 per cent in wheat on fallow, 6.5 per cent in second crop wheat and 10.3 per cent in third crop oats. For the past ten years the wild oats content in grain on all fields in the six-year rotation has never reached measurable proportions. There is now a mere trace and in the cultivation of the fields the problem of wild oats is never considered. On the other hand cultivation on the straight grain rotation is constantly done in deference to the problem of wild oats and in spite of employing all the best known tillage methods over a long period of years the infestation appears to increase. There is evidence here that unless some new method or methods are devised for controlling wild oats in grain rotations all the best known methods used up to the present time only provide sporadic relief.

(2) Fall seeded winter crops. Grain crops seeded on fallow having a clean surface, in late August or early September establish sufficient growth early in the spring to compete successfully with wild oats. Winter wheat and winter rye are both useful grain crops for controlling wild oats.

(3) Cleaning Rotations. On farms where forage is a necessity land infested with wild oats can be satisfactorily cleaned up by two or more rounds of the following rotation. Fallow, wheat, oats for green feed or wheat, oats for green feed seeded to sweet clover, clover hay and break in place of fallow.

CHEMICAL CONTROL OF WILD OATS (AVENA FATUA)

H.W. Leggett, Dominion Experimental Station,

Lacombe.

In view of the fact that wild oats is the principal weed infecting Western Canadian grain crops and because cultural control methods have failed to achieve any marked success, the use of chemicals as a means of control are being tested. While no sure method has, as yet, been completely successful some progress has been made which is worthy of attention.

Whenever wild oats is discussed, two of its characteristics are always in evidence, and both of these contribute greatly to its weediness. The first outstanding trait exhibited by wild oats is dormancy of the seed. This characteristics accounts for the build-up, in the soil, of countless seeds where they complicate control measures by germinating at odd intervals over a period of years. The second prominent feature of wild oats is its habit of early shattering which helps to perpetuate its own almost as rapidly as others of their own are killed. These two characteristics of wild oats have channeled chemical control investigations along two separate lines, either of which would, if successful, eliminate the wild oat as our principal weed. The first method has aimed at destruction of the wild oat population in the soil while the second has as its aim the elimination of wild oat plants from a crop.

Destroying the wild oat population in the soil has been further divided into two classes, one which would destroy the seeds in the soil by the use of temporary soil stirilants and the other by means of pre-emergent sprays which would destroy the germinating seedlings without harm to the following crop.

Temporary Soil Stirilants

The use of soil stirilants of a more or less temporary nature has received some attention this past year. A few of the main chemicals used in this field include T.C.A., C.M.O., IPC, etc. Their use has been confined to land which is in summerfallow or late fall applications to land that has produced a crop.

Ebell and Corns, at the University of Alberta, found that a stand of wild oats was significantly reduced with T.C.A. at 20, 40, and 80 pounds per acre.

Wilson of California in a previous N.C.W.C.C. report stated that I.P.C. applied either in the late fall or early spring remained effective for five to six weeks and that weed control was affected when the expanding embryo came into contact with the chemical in the soil.

Dunhouse et al using I.P.C. and Chlorol I.P.C. in previous N.C.W.C.C. reports had several promising results but have been unable to duplicate them this year.

Corns, at the University of Alberta, using T.C.A., C.M.U. and granular cyanamid, found that T.C.A. at 50 pounds per acre, applied on summerfallow prevented emergence, or gradually killed those which did emerge with very good results. He also found that by mid-summer the pigweed growth on these plots was abundant.

At the Lacombe Experimental Station C.M.U. applied, in 1951 on land very heavily infested with wild oats, at rates of 20, 40, 80 and 100 pounds showed practically 100 percent control of wild oats even on plots sprayed with 20 pounds of C.M.U. Any of the wild oats that did emerge never developed to maturity. However the soil sterility effect lasted throughout the 1952 season and therefore could hardly be used in conjunction with a summerfallow year.

W.A. Hedlin, Agriculturist, reports that an application of 50 lbs. of cyanamid increased the germination of wild oats, the following spring, where they were easily killed by cultivation. One year later Hedlin found that there was a visible difference in the number of wild oats in the mature grain stand.

The use of temporary soil stirilants in combating the wild oat menace may prove beneficial if the proper chemical can be found and the method of application is determined. As is evident from the abstracts, there are indications that temporary soil stirilants may possibly hold the answer for controlling, not only wild oats but other weeds whose seeds infest the soil.

Pre-emergence Treatments.

The use of chemical sprays which would destroy the germinating plants previous to seeding a crop would be of value in wild oat work. Ebell, of the University of Alberta, states that with a method of this type the soil would be left relatively undisturbed, new growth of wild oats would not be encouraged and the crop could be seeded up to six days earlier.

Coupland, at the University of Saskatchewan, found that wild oats were practically eliminated with 20 to 40 pounds of T.C.A. per acre. Next in order of effectiveness was 10 pounds of T.C.A., C.I.P.C. at 20 and 40 pounds, and C.M.U. at 4 pounds.

Ebell and Corns, of Edmonton, found that I.P.C. and IPC and granular cyanamid resulted in considerable kill and stunting of wild oat plants. Plant counts data showed no significant kills from various rates of M.H., C.M.U. or Napthyl Pthalmic acid.

Very little work has been reported on the effect of pre-emergent sprays, such as have been mentioned, on crop plants. Considerable variation is evident in those results presented. However, the field of pre-emergence spraying should not be overlooked because it is a method, which if successful, would prove popular.

Post-Emergence Treatments

Post-emergence treatments on wild oats have followed two lines of endeavor. One being to sow the crop into the infested soil then after three days to spray the top growth of wild oats with a chemical which would destroy all of this top-growth but have no effect on the later germinating crop; the second line being the use of a selective spray to eliminate wild oats from a growing crop.

Knowles of the Central Experimental Farm has found that M.H. causes sterility when applied on cereal crops before fertilization takes place and since wild oats come into head approximately one week later than Montcalm barley or Thatcher wheat it is possible to spray when the crop is immune (i.e. after fertilization) and the wild oats susceptible when they will be left sterile by the spray.

Ebell of Edmonton states that chemicals toxic to germinating seedlings yet harmless to emerged crops would be beneficial and that some chemicals of this type have been developed such as dichloral urea and 2,4-dichlorophenoxyethyl sulfate etc. Ebell further states that post-emergence methods of control would be preferable than pre-emergent spraying in that it would eliminate the critical timing necessary for successful pre-emergence control. At Lacombe we have found that six pounds of M.H. has reduced the population of wild oats. The M.H. was used when the wild oats were 10 to 12 inches in height and the crop was just emerging. No appreciable damage was recorded on the crop.

While it may be said that very little has been accomplished as far as chemical control of wild oats is concerned, it must be remembered that a lot of work has gone into what has been accomplished. In my opinion the past chemical control studies have at least pointed the way and our results so far are far from discouraging.

ABSTRACTS

Response of wild oats to soil treatments with granular cyanamid, CMU and TCA Corns, W.G. With the aim of testing short-term soil-sterilization as chemical summerfallow, wild oats obtained from commercial screenings were planted on May 16 at 2 bus./ac. in spring-plowed land at Edmonton. Quadruplicate randomized plots were treated immediately after seeding. Treatments were granular cyanamid, Rates 1, 2, 3 ; 200, 300, 400 lbs./acre spread dry; CMU:1, 5, 10 lbs./acre in 50 gal. water spray; sodium TCA: 10, 25, 50 lb./A in 50 gal water. Soil was disced immediately after application of chemicals. First major rainfall occurred 5 days later. Fresh weights of wild oat plants on 66 square feet were taken soon after heading time and expressed as mean percentage of check yield in the following table:

	Rate 1	Rate 2	Rate 3
Granular Cyanamid	96	100	93
CMU	105	109	94
TCA	80	50	24
Check (Approx.14 tons/A)			

TCA acted mainly by prevention of emergence and partially by gradually killing emerged plants. On plots kept nearly bare by Rate 3 TCA, there was abundant growth of pigweeds etc. after mid-summer. Work with TCA is being extended to include fall applications to wild oats followed by spring and fall grain crops. (Contributed by Department of Plant Science, University of Alberta, Edmonton).

Fall application of TCA on wild oat infested soil

Ebell, L.F. and W.G. Corns On September 21, 1952, two days after wild oats were sown, soil applications of TCA were made at the rates indicated in the table. Germination was good though growth was slow due to fall weather conditions. Check plants were in the 2-3 leaf stage on October 17, when two ½ rod row samples **per plot were taken. See Table 5 Page 26 .** data over the various rates were as follows: Average of four replicates.

On both sets of data the reduction in wild oat stand was significant at the 20, 40 and 80 lb. rates, and also at the 10 lb. rate for green weight data. Further differences probably would have resulted with **time.** The plots are of sufficient width to allow two **seedings** of crop to be made at different dates next spring and summer in order to test for possible residual effects of TCA. (Contributed by the Department of Plant Science, University of Alberta, Edmonton, Alberta).

Effect of Various Herbicides on Oats, Barley and Flax

Ebell, L.F. **This experiment was conducted during the summer of 1950 at the Green Cross Insecticides station at Rougemont, Quebec to obtain indications whether wild oats could be killed by chemicals without adverse effects on established and later emerging crop plants. Cultivated oats to simulate wild oats were sown the length of the experiment and allowed to emerge to the 2-leaf stage. Barley and flax were then sown at right angles and the chemicals applied two days later, on July 1. Weight of mature plant samples of each crop were taken for a 4 sq. feet area in each plot. Data for the various crops following the indicated treatments are found in Table 6 Page 26.**

The PCP and MH almost completely eliminated the oats at the high rates and showed no damage to the barley and flax. Barley yield was significantly increased due to partial freedom from oat competition. Conversely, the Dichloral Urea being toxic to germinating seeds reduced the stand of barley and flax somewaht though not significantly. The oats seemed to derive some additional beneficial effect, tillered more freely and exhibited a deeper green. Some fertilizer effect may have occurred through foliage absorption of urea. Post emergence treatment with dichloral urea and related chemicals may prove to be of great value in suppressing weed growth in established crops. (Contributed by the Department of Plant Science, University of Alberta, Edmonton.)

Effects of pre-emergence applications of various herbicides on wild oats at early germination stage Ebell, L.F. and W.G. Corns
On September 22, 1952, two days after seeding wild oats, soil applications of MH, IPC, CMU, IPC plus cyanamide were made at the following rates. MH -2.5, 5, and 10 lb/A; IPC - 2.5, 5, and 10 lb/A; CMU- 5, 10, and 20 lb/A. IPC and cyanamide combinations were

as follows: 2.5, 5, 10 lb/A and 100, 200 and 400 lb/A of IPC and cyanamide respectively. On September 29, one to two days before wild oat emergence, N-1 Napthyl Phalamic acid was applied at 2.5, 5 and 10 lb/A. On October 16 and 17 data were taken using two ¼ rod rows from each plot. Plants were in the 2-3 leaf stage. Plant count and green weight data for each of the various treatments were analyzed statistically. IPC and IPC plus cyanamide treatments resulted in considerable kill and stunting of plants. Plant count data indicated no significant kill from MH, CMU or Napthyl Pthalmic acid. Green weight data revealed a significant stunting effect from MH and CMU. Observations will be made on remaining plants until freeze-up. (Contributed by the Department of Plant Science, University of Alberta, Edmonton, Alberta).

Effects of various herbicides on wild oats (Avena fatua L.) when applied as pre-emergence sprays, 1952. Coupland, R.T.

Rod row plots of wild oats were treated with duplicate applications of the following herbicides on June 9 (three days after seeding): CIPC at 10, 20 and 40 lb/A. in 50 gal. of water, TCA at 10, 20 and 40 lb/A. in 20 gal. of water, CMU at ½, 1, 2 and 4 lb/A. in 50 gal. of water and DNOSBP (Dow Premerge) at 4, 8 and 12 qt/A. in 40 gal. of water. Wild oats were practically eliminated by the TCA at 20 and 40 lb. Next in order of effect on wild oats were TCA at 10 lb., CIPC at 20 and 40 lbs., and CMU at 4 lb. Other treatments did not result in effective control. All volumes are in Imperial measure. (Contributed from the Department of Plant Ecology, University of Saskatchewan, Saskatoon, Saskatchewan).

Selective control of wild oats in cereal crops by Maleic Hydrazide. Knowles, G. On an area infested with wild oats obtained from Alberta one drill width of each of the following cereal crops was seeded in parallel strips in the spring of 1952, Montcalm barley, Thatcher wheat, Cartier oats and Red Wing flax. Across these drill width three rates of maleic hydraxide (amine sticker) were applied at three day intervals from the time the wheat and barley were in the fourth leaf stage until six days after the wheat and barley were in head. The three rates of maleic hydrazide were used were 1, 1½ and 2 pounds (active ingredients) per acre. All treatments except those which were applied on the last treatment date caused almost complete sterility of all cereal crops and wild oats. The last treatment, however, caused almost complete sterility of wild oats and cultivated oats but only partial sterility of barley, wheat and flax. The growth stage of wild oats and each cereal crop when the final treatments were applied was as follows:- Barley and wheat had been in head for six days, flax was in late bloom, the oats and wild oats were in the late shot-blade stage.
Conclusions: The results from this experiment indicate (1) maleic hydrazide causes sterility when applied on cereal plants before fertilization takes place,(2) cereal plants become less susceptible to sterility from maleic hydrazide soon after fertilization and (3) since wild oats come into head about one weed later than Montcalm barley and Thatcher wheat it should be possible to control wild oats in early varieties of cereal crops by treating them with maleic hydrazide when these crops have entered the immune period of growth and while the wild oats is still in the susceptible stage. (Contribution of Central Experimental Farm, Ottawa, Canada).
See Tables 7 & 8, Page 26.

CONTROL METHODS FOLLOWED IN THE UNITED STATES

E.A. Helgeson, North Dakota Experimental Station

As stated by Mr. Wood, this annual weed pest is pretty well scattered throughout the country but is only a serious pest in our spring wheat area. We in North Dakota would certainly rate the wild oat as our most serious annual weed, and also as the most serious weed pest we have to deal with.

Control measures in general use in the United States are similar to those employed in the Canadian Prairie area. With the emphasis on spring grains and the absence of a long-time rotation which includes pasture, hay or the frequent use of a clean cultivated crop, the problem of control becomes most acute. In states where a rotation such as fall rye, clover for hay followed by corn is used, this weed has ceased to be major factor. Since a mixed farming scheme seems to be one answer to the control of wild oats, it may be necessary to make a shift in this direction in the plains states.

Control measures in general use at present are based upon cultural practices which produce favorable conditions for the germination of seeds and the subsequent destruction of seedlings by tillage. Since germination in the fall is usually sparse a light covering of soil to induce early spring emergence is desirable. Delayed seeding of the crop in the spring in order that several crops of sprouting oats may be destroyed by repeated cultivation, is an important phase of this control method.

Sowing of fall rye or an early maturing variety of crop which may be harvested before the wild oat seeds are formed is also of value. Care should be taken to see that hay produced under these conditions does not contain seeds which may pass through the animal and re-infest the land.

Probably the most effective cultural control is obtained where an area can be laid down to grass or a perennial legume such as alfalfa which later can then be used as pasture or hay for a period of five years or so. If then this pasture or hay phase is followed by a clean tilled crop and then by small grain, good control can be expected.

An important part of any control practice must include measures which will prevent the spread or re-infestation on any area. If screenings containing wild oats are to be fed, they should be well-ground to destroy the oat seed. Hay infested with wild oats should not be moved off the farm and should be cut early enough to prevent ripening of the seed. Seeding and harvest equipment should be kept free of seeds.

Some work on chemical control is under way in several states. In Colorado, Oregon, and California I.P.C. appears effective. Our work in North Dakota shows no promise for this chemical. T.C.A. will kill wild oats but in our state amounts around 60 pounds per acre must be applied. C.M.U. applied at four pounds per acre in flax gave good control in trials conducted by McDonald this year. Several years work with Endothal has shown promise as a control measure for wild oats in sugar beets. Six pounds per acre either as pre-emergence or post-emergence treatment gave excellent control in 1951 and fair control in 1952 in our trials at Fargo. In greenhouse studies we found that direct spraying of wild oat seeds on the soil surface with oils or Endothal reduced the subsequent germination of seeds by 50 per cent and delayed the growth of those seeds which did sprout by at least two weeks. These results indicate that it may be possible to kill wild oat seeds before they are plowed under.

Table 1
Data obtained on abundance of persistent perennial weeds from the Saskatchewan Weed Survey, based on the 1952 detailed survey of 12 municipalities.(Preliminary as of Sept. 10, 1952.)

Species	No. of infested. Municipalities	Quarter sections	Acres
Leafy spurge	9	24	576
Toadflax	11	229	523
Hoary cress	7	48	537
Russian ; knapweed	6	58	1608
Field bindweed	8	29	255
Poverty weed	4	19	31

Table 2
Data obtained on abundance of persistent perennial weeds from the Saskatchewan Weed Survey, based on the 1949, 1950, 1951 and 1952 Surveys in 70 municipalities. (Preliminary as of Sept. 10, 1952.)

Species	No. of infested Municipalities	Quarter sections	Acres
Leafy spurge	55	517	7948
Toadflax	50	3187	29005
Hoary cress	27	96	1333
Russian knapweed	24	83	1664
Field bindweed	33	106	1332
Poverty weed	15	54	991

Table 3
Area Infested with Perennial Weeds by Provinces.

	Manitoba	Saskatchewan	Alberta	British Columbia
Leafy spurge	8,000 acres	8,000 acres	248 patches	100 acres
Toadflax	occasional patches	40,000 acres	1,275 acres	scattered small patches
Hoary cress	few single patches	1,300 acres	825 patches	600 acres
Field bindweed	4,500 acres	1,300 acres	59 patches	1,000 acres
Russian knapweed	None	1,600 acres	66 patches	75 acres
Bladder Campion	343 acres and a few patches	a few patches	very few patches	Scattered

Table 4
Percentage of wild oat varieties in population at five Experimental Stations in western Canada.

Station	Pilosissima	Glabrata	Intermedia	Vilis
Beaverlodge, Alta.	9	0	53	38
Lacombe, Alta.	10	2	86	2
Melfort, Sask.	7	7	43	43
Indian Head, Sask.	54	4	20	22
Brandon, Man.	30	3	50	17

Table 5

	Response to TCA 5lb/A	10lb.	20 lb.	40 lb.	80 lb.	Check
Plant count	152.8	118.2	88.8	82.5	41.2	173.2
Green Weight in grams	13.15	10.10	6.88	5.48	1.62	18.40

LSD at 5% - Plant Count 64.4; Green Weight 7.07

Table 6
Various Herbicides - Ave. Four Replicates.

Treatments	Rates per acre	OATS Chemicals	Rates	BARLEY Chemicals	Rates	FLAX Chemical
Sulphasan	3 qt. 101.0		34.0		24.7	
	6 qt. 68.0		46.7		24.7	
	12 qt. 42.0	70.3	48.7	43.1	31.3	26.9
PCP	2.5 lbs. 66.3		57.0		33.0	
	5 lbs. 29.3		59.7		40.0	
	10 lbs. 15.7	37.1	77.7	64.8	33.3	35.4
MH	1.7 lbs. 38.7		63.3		39.7	
	3.4 lbs. 3.0		64.7		27.0	
	6.8 lbs. 1.7	14.5	78.7	68.9	26.3	31.0
Urea Dichloral	2.5 lbs. 115.3		21.7		19.0	
	5 lbs. 131.3		27.3		20.0	
	10 lbs. 142.7	129.8	12.0	20.3	20.3	19.8
Check		73.6		34.8		28.2
LSD for chemicals		23.0		15.5		---

Table 7
The effect on the heads of barley, wheat and flax sprayed with one pound per acre (active ingredient) of maleic hydrazide when the wild oats were in the late shot blade stage.

Crop		% Normal Heads	% Partly sterile Heads	% Sterile Heads
Barley	Treated	87	4	9
	Check	96	4	0
Wheat	Treated	75	16	9
	Check	90	10	0
Flax	Treated	Yield of seed from 100 plants		4.1 gms
	Check	Yield of seed from 100 plants		7.3 gms

Table 8
The effect on the germination of the seeds of barley, wheat, flax and wild oats sprayed with one pound per acre (active ingredient) of maleic hydrazide when the wild oats were in the shot blade stage.

Kind of Seed	Treated Average, 4 Replicate	Check Average, 4 Replicate
Flax	95% Germination	96% Germination
Barley	89% Germination	96% Germination
Wheat	9 % Germination	92% Germination
Wild oats*	6.9% Germination	62.4% Germination

* Average of 10 Replications.

PENETRATION AND TRANSLOCATION OF 2,4-D COMPOUNDS

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Although 2,4-D is the most widely used and extensively studied herbicide, the mechanism of its toxic action remains relatively obscure. The factors contributing to the effectiveness of growth regulant type herbicides may be conveniently divided into: (a) absorption or penetration, (b) translocation, and (c) toxic action. Previous studies have indicated that penetration of sodium 2,4-D is increased by increases in temperature or by the addition of wetting agents to the spray solutions and that downward translocation in woody species is greatest when the carbohydrate supply of the roots is being replenished after spring growth. However, there seem to be few investigations which describe and compare the penetration and translocation rates of different 2,4-D compounds.

Methods and Materials

To measure penetration effects, soybean plants were grown in 4-inch pots and treated when the unifoliate leaves were expanded and the first trifoliate leaves were still in the bud. A pot of 3 plants was the experimental unit and uniform units were grouped into 4 to 6 replications. Each pot was placed on a revolving turntable in a spray chamber and 10 ml. of aqueous 2,4-D solution was sprayed on each pot with a paint gun. After specified periods of time the sprayed plants were washed thoroughly in a series of water-Dreft solutions and then in tap water to remove the unabsorbed 2,4-D residues.

Translocation was studied by immersing one-half of one unifoliate leaf into the material to be tested and observing the effect on the terminal growth of the plant. In some time studies, the treated leaf was clipped from the plants at various intervals to remove the source of 2,4-D, and injury to the plant was then used as a measure of the rate of penetration into and translocation from the leaf before its removal. All of the new growth above the unifoliate leaves was harvested 10 - 14 days after treatment and the green weights recorded. The amount of penetration or translocation which occurred was assumed to be inversely proportional to the weight of new growth. The following compounds of 2,4-D were used: (a) sodium salt, (b) dimethylamine, (c) isopropyl ester, and (d) a low volatile ester. The wetting agents used were (a) Triton B-1956(nonionic), (b) C-61 (cationic), (c) Hyamine 2389 (cationic), (d) Tergitol 7 (anionic), and (e) Triton X-100 (nonionic). Hyamine 2389 and Triton X-100 were slightly toxic to soybean plants; the other wetting agents did not exhibit direct toxicity during a one hour exposure period at a concentration of 0.5 percent.

Results and Discussion

Several investigators have shown that the toxicity of 2,4-D may be increased by the addition of surface active agents to spray solutions. The effect of several wetting agents on the penetration of sodium 2,4-D (100 ppm.) is shown in Table 1. The sodium salt did not penetrate during a 60 minute exposure, but when wetting agents were added, penetration occurred in 30 minutes. When the concentration of the chemical was increased ten times (Table 2), sodium 2,4-D without adjuvants did not penetrate the plant tissues during a 15 minute exposure,but if wetting agents were added to the spray solutions, significant penetration occurred in 4 minutes. Addition of surface active agents to solutions of 75 ppm. of the dimethylamine form reduced the time required for penetration (Table 3). When the concentration was increased to 750 ppm., exposures of 4 minutes with and 7 minutes without adjuvants were required for penetration (Table 4). The absorption rates of the isopropyl ester were strikingly different from those of the sodium and amine compounds. The data in Table 5 show that the isopropyl ester penetrated rapidly, yet the addition of surface active agents usually speeded entrance of the chemical into plant tissues. However, when C-61 was used with the ester solutions, penetration was decreased, especially during the shorter exposure periods. In another experiment, solutions of 100 ppm. of the isopropyl ester were sprayed and short exposure intervals were used (Table 6). The plants in the 0-exposure series were washed immediately after the spraying process which lasted approximately one minute. The data indicate that penetration of the ester began immediately after application and was very rapid during the first few minutes.

Beevers et. al., using a malonate inhibition system, obtained evidence that undissociated ester molecules penetrated cells more rapidly than free acid molecules. According to Crafts, non-polar molecules dissolve in and pass through cuticle more readily than do polar or water soluble molecules. Comparisons of the data in Tables 1-6 show that the non-polar ester molecules penetrated rapidly, whereas the polar sodium salt was absorbed very slowly. The amine form was intermediate. Addition of surface active agents to the spray solutions tended to decrease the absorption differentials of the 2,4-D compounds used.

The effect of the reserve carbohydrate supply on penetration of 2,4-D was studied by dipping plants previously held in darkness into 2,4-D solutions and then washing the 2,4-D from the plants after specified exposure periods. The data in Table 7 indicate that reserve carbohydrates were not a critical factor influencing the penetration rates of 2,4-D.

In contrast, other experiments showed that definite positive relationships existed between translocation of 2,4-D and the presence of carbohydrates, either within the leaf or externally applied. Soybeans that were grown in the light and treated with 500 ppm. 2,4-D on one half unifoliate leaf died when placed in the dark. Beans placed in the dark 48 hours before treatment showed no 2,4-D effects until returned to the light or treated with a sugar solution. Plants placed in reduced light or darkness before treatment and returned to the light after treatment showed greater translocation of 2,4-D than plants kept in the light before treatment. Plants placed in the dark before treatment then treated with sucrose and with 2,4-D one hour later and kept in the dark showed no 2,4-D effects. Similar plants treated with 2,4-D and then with sucrose showed 2,4-D effects.

Translocation of 2,4-D was studied with plants held at 70°F. and others held at 40°F. for 48 hours after treatment with an ester of 2,4-D. The treated leaf of the plants was removed at intervals of 4, 8 and 24 hours; yields were compared to those with the treated area not removed and with control plants. At 40°F. there was no translocation out of the treated area until the plants were returned to the heated greenhouse. At 70°F. significant translocation occurred after 4 hours contact with the leaf (Table 8.)

Tests with the amine of 2,4-D, with and without a wetting agent, and with a low volatile ester showed no significant differences in translocation. The average weight of the terminal growth of the treated plants for 24 treatments was 1.87 grams for amine plus wetting agent, 1.77 for ester, and 1.63 for amine alone.

To test the effect of soil moisture on the translocation of 2,4-D, some plants were grown with soil moisture held near the field percentage, and others were watered to field percentage only after the plants had nearly reached the permanent wilting percentage. The dry treatments reduced growth of the plants 20 percent and translocation 7 percent (Table9).

Concentrations of 2,4-D from 100 to 10,000 ppm. were used with a toxic (Triton X-100) and a non-toxic wetting agent (Triton B-1956). The wetting agents were used at concentrations of 0.5 percent. When the non-toxic wetting agent was used, translocation of 2,4-D was proportional to the concentration of 2,4-D. When the toxic wetting agent was used, translocation of 2,4-D did not occur above concentrations of 500 ppm. No translocation of 2,4-D occurred when 1000 ppm. DNOSBP or toxic oils were applied with 500 ppm. 2,4-D. In these cases,the treated portion of the leaf was injured. The initiation of injury was evidently fast enough to prevent the movement of the 2,4-D from the treated leaf area (Table 10).

Summary

The principal results of the experiments described in this paper may be summarized as follows:

1. The isopropyl ester of 2,4-D penetrated soybean plants rapidly, the sodium salt was absorbed slowly, while the amine was intermediate in rate.

2. The rates of absorption of all the 2,4-D compounds were increased when surface active agents were added to the spray solutions.

3. The rate of effective penetration was more rapid as the concentration of 2,4-D per unit volume of solution was increased.

4. A reserve carbohydrate supply was not essential for penetration of 2,4-D but was essential for translocation.

5. Translocation of 2,4-D was slowed or stopped when plants were held at low temperatures but occurred when treated plants were returned to normal temperatures.

6. Amines and esters appeared to be translocated equally well in plants.

7. Translocation of 2,4-D was not significantly reduced when plants were under stress for moisture.

8. Toxic materials combined with 2,4-D may reduce translocation of the latter by injuring the translocating tissues.

Table 1. New growth of soybeans treated with Na 2,4-D, 100 ppm., with and without added wetting agents (0.5 percent).

Treatment	Green weight, new growth in grams				
	Exposure interval				Treatment means
	7 min.	15 min.	30 min.	60 min.	
2,4-D + Triton B-1956	3.03	2.88	1.36	1.13	2.10
2,4-D + C-61	3.10	2.64	1.97	0.89	2.15
2,4-D + Tergitol 7	2.91	2.64	1.72	1.65	2.23
2,4-D	3.56	3.19	2.95	3.15	3.21
2,4-D, not washed	1.72	2.27	2.35	1.45	1.95
Untreated check	3.41	2.98	3.46	3.12	3.24
Interval means	2.96	2.77	2.30	1.90	

L.S.D.'s: Treatment means - (.05) = 0.74 gm.
(.01) = 0.98 gm.

Interval means - (.05) = 0.96 gm.
(.01) = 1.34 gm.

Each figure is the average of 4 replicates.

Table 2. New growth of soybeans treated with Na 2,4-D, 1000 ppm., with and without added wetting agents (0.5 percent).

Treatment	Green weight, new growth in grams			
	Exposure interval			Treatment means
	4 min.	7 min.	15 min.	
2,4-D + Hyamine 2389	0.67	0.38	0.05	0.37
2,4-D + Tergitol 7	1.24	0.35	0.25	0.61
2,4-D	2.49	1.81	2.09	2.13
2,4-D, not washed	0.04	0.02	0.00	0.02
Untreated check	2.16	1.92	2.02	2.03
Interval means	1.32	0.90	0.88	

L.S.D.'s: Treatment means - (.05) = 0.20 gm.
(.01) = 0.27 gm.

Interval means - (.05) = 0.21 gm.
(.01) = 0.30 gm.

Each figure is the average of 5 replicates.

Table 3. New growth of soybeans treated with amine 2,4-D, 75 ppm., with and without added wetting agents (0.5 percent).

Treatment	Green weight, new growth in grams				
	Exposure interval				Treatment means
	7 min.	15 min.	30 min.	60 min.	
2,4-D + Triton B-1956	2.13	1.88	1.10	1.02	1.53
2,4-D + C-61	1.73	1.41	1.26	1.11	1.38
2,4-D + Tergitol 7	1.89	1.66	1.42	1.76	1.68
2,4-D	2.16	1.97	2.27	1.94	2.09
2,4-D, not washed	0.94	0.90	0.92	0.85	0.90
Untreated check	2.98	2.78	2.42	2.71	2.72
Interval means	1.97	1.77	1.57	1.57	

L.S.D.'s: Treatment means - (.05) = 0.24 gm.
(.01) = 0.32 gm.

Interval means - (No significance)

Each figure is the average of 5 replicates.

Table 4. New growth of soybeans treated with amine 2,4-D, 750 ppm., with and without added wetting agents (0.5 percent).

Treatment	Green weight, new growth in grams			
	Exposure interval			Treatment means
	4 min.	7 min.	15 min.	
2,4-D + Hyamine 2389	0.17	0.16	0.05	0.13
2,4-D + Tergitol 7	1.49	0.39	0.06	0.65
2,4-D	2.47	1.99	1.02	1.83
2,4-D, not washed	0.00	0.00	0.00	0.00
Untreated check	2.52	2.46	2.17	2.38
Interval means	1.33	1.00	0.66	

L.S.D.'s: Treatment means - (.05) = 0.22 gm.
(.01) = 0.29 gm.

Interval means - (.05) = 0.15 gm.
(.01) = 0.21 gm.

Each figure is the average of five replicates.

Table 5. New growth of soybeans treated with ester of 2,4-D, 50 ppm., with and without added wetting agents (0.5 percent).

Treatment	Green weight, new growth in grams				
	Exposure interval				Treatment means
	7 min.	15 min.	30 min.	60 min.	
2,4-D + Triton B-1956	2.14	1.32	0.94	0.56	1.24
2,4-D + C-61	2.31	2.47	1.97	1.68	2.11
2,4-D + Tergitol 7	0.93	0.40	0.43	0.74	0.62
2,4-D	1.73	1.90	0.99	1.03	1.42
2,4-D, not washed	1.39	0.85	1.17	1.18	1.15
Untreated check	3.29	3.85	3.85	3.51	3.63
Interval means	1.97	1.80	1.56	1.45	

L.S.D.'s: Treatment means - (0.5) = 0.24 gm.
(.01) = 0.32 gm.

Interval means - (.05) = 0.25 gm.
(.01) = 0.35 gm.

Each figure is the average of six replicates.

Table 6. New growth of soybeans treated with ester of 2,4-D, 100 ppm., with and without wetting agents (0.5 percent).

Exposure interval	Green weight, new growth in grams		
	2,4-D	2,4-D + T-7	Check
0 min.	1.38	1.36	1.71
1 min.	1.22	0.95	-
2 min.	1.09	0.80	-
4 min.	0.94	0.51	-
Unwashed	0.63	0.29	1.71

L.S.D.'s: Treatments - (.05) = 0.35 gm.
(0.01) = 0.47 gm.

Each figure is the average of four replicates.

Table 7. Effect of reserve carbohydrate supply on penetration of amine 2,4-D, 500 ppm. plus Tergitol 7 (.25 percent).

Treatment	Treatment conditions	
	Darkness 48 hrs before and 24 hrs after treatment, gms. new growth.	Light before and after treatments, gms. new growth.
Treated and washed immediately	3.99	-
Treated and washed after 24 hours	0.00	0.00
Check	4.14	5.12

L.S.D.: Treatment - (.05) = 0.92
(.01) = 1.28

Each figure is the average of four replicates.

Table 8. Temperature and translocation of 2,4-D.

Treatment time	Av. weight new growth, gm. [1]	
	Plants at 70°F.	Plants at 40°F.
Control	4.16	2.66
Treated[2] 4 hours	3.05 *	2.32
8 hours	3.13 *	2.51
24 hours	2.72 **	2.15
10 days	1.99 **	1.26 **

L.S.D. (05)* .93
(.01)** 1.33

1 For 48 hours after treatment
2 2,4-D at 500 ppm on one half of one unifoliate soybean leaf

Each figure is the average of four replications.

Table 9. Soil moisture and translocation.

	Av. weight new growth, gms. Plants grown with	
	Adequate moisture	Near wilting percentage.
Control	4.37	3.44
Treated[1]	2.50 **	1.71 **
Reduction	57%	50%

1 2,4-D at 500 ppm on one half of one unifoliate soybean leaf.

Each figure is the average of four replications.

Table 10. Toxicity and translocation.

2,4-D treatment[1]	Av. weight new growth, gms.	
	0.5% Toxic wetting agent	0.5% Non-toxic wetting agent
100 ppm.	3.52 *	3.40
500	2.60 **	2.62 **
2000	3.90	1.81 **
5000	4.02	1.52 **
10000	4.48	1.46 **
Control	4.64	3.95
500 + DNOSBP 1000	4.21	
500 + TCA 2000	2.66 **	
TCA 2000 (alone)	3.87	

1 Applied to one-half unifoliate soybean leaf - 1.20*, 1.83**

Each figure is the average of four replications.

TRANSLOCATION OF HERBICIDES IN LEAFY SPURGE

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Recent surveys indicate that there are some 8000 acres of Leafy Spurge in Western Canada. In Eastern Canada infestations are largely in Ontario, with hardly a county free from this pest or its relative, Cypress Spurge. Since Leafy Spurge is very resistant to eradication by cultivation, its handling on a farm presents a major problem. A satisfactory chemical procedure for its eradication would therefore be of great economic value.

The chemical 2,4-D has been partially successful against Spurge although repeated treatments, often over several years, may be necessary to hold it in check. Typically the 2,4-D penetrates to the lower stem, or to the crown, and there its movement is checked. Dominance of one or two growing shoots over the lateral buds on the crown appears to be important with respect to persistence of this weed to cultural or chemical control measures.

The experiments reported here on Leafy Spurge are part of a project on the movement of 2,4-D in perennial weeds. With Spurge we were interested in some method of upsetting the translocatory blocks to 2,4-D that appear to exist in the crown of this weed. Our work in this field developed along three lines:

1. The effect of repeated treatments of 2,4-D at different concentration levels.
2. The effect of directed treatments.
3. The effect of 2,4-D treatments in relation to the treatment of plants with other chemicals.

Repeated Treatments

The following experiments were conducted in the repeated treatment tests:

1. Na 2,4-D at 500 p.p.m., B.E. 2,4-D at 250 and 500 p.p.m. were applied as repeated dosages to Leafy Spurge plots in treatments starting May, June, July and August, 1952. Single treatments with these chemicals were compared with 6 treatments 24 or 48 hours apart.
2. Na 2,4-D at 500 and 1000 p.p.m. and B.E. 2,4-D at 250, 500 and 1000 p.p.m were applied in repeated treatments starting July 18/52. Single treatments were again compared with 6 treatments at 24 or 48 hour intervals.
3. Na 2,4-D at 1000 p.p.m. was applied to Leafy Spurge plants in greenhouse pots. Single treatments were compared with 6 treatments at 2,4,8, 12, 24 and 48 hour intervals. Treatments were made starting May 29 and June 26, 1952.

Repeated treatments in general increased the amount of "Crown" damage from the 2,4-D. The increases were surprisingly light in relation to the total dosage used. There was no evidence (within the concentrations used) to support the thesis that low dosages moved more readily into the Spurge plant than did higher ones.

Directed Treatments

Cotton swabs soaked with 2,4-D attached to Spurge stems 3 inches above the ground showed that 2,4-D may enter the Spurge plant through the stem. Concentrations of Na 2,4-D at 2500 and 5000 p.p.m. affected the top growth to varying degrees. B.E. 2,4-D at 1500 and 3000 p.o.m. killed the above ground plants and the 3000 treatment did marked injury to the crown.

Combination Treatments

Here an attempt was made to upset the normal physiology of the plant with a chemical treatment dosages moved more readily into the Spurge plant and then to apply 2,4-D. A series of treatments using 1% sugar with 2,4-D, on both starved and unstarved plants gave no enhancement of 2,4-D effect.

Sodium lauryl sulfate (1%) and Vitamin K (100 /ml.) and potassium acid carbonate (1%) were used with 2,4-D with no positive results.

Bayol D, a low aromatic oil, increased the effect of the 2,4-D in certain treatments. A similar response was observed from 2,4-dichloroanisole ($Cl_2C_6H_3OCH_3$).

Maleic Hydrazide at concentrations of 1000, 2000 and 4000 p.p.m. was applied to Spurge plots every two weeks from May 23 to August 11, 1952. Top growth on the 4000 p.p.m. plot was killed in about 50 percent of the plants. A 1000 p.p.m. treatment with Na 2,4-D after the above M.H. treatments severely injured the top growth but did not affect the crown.

Maleic Hydrazide was applied at concentrations of 1000, 2000 and 4000 p.p.m. on May 23, June 16 and August 8, 1952. Single stems from the treated plots were sprayed with Na 2,4-D at 1000 p.p.m. at 1, 3, 5 or 7 days after the M.H. pre-treatment. With the May treatment 2,4-D applied 5 days after, the M.H. showed greater effect on the Spurge crown than did other treatments or checks.

Preliminary results indicate that a treatment under investigation has a marked effect on stimulating regrowth from Spurge crowns and may have value in conjunction with 2,4-D treatments.

THE EFFECT OF 2,4-D ON PLANT ENZYMES

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The purpose of this review is twofold (1) to suggest ways whereby enzymatic action may be altered and to fit 2,4-D into this picture if possible, and (2) list some of the reported effects of 2,4-D on individual enzymes or systems.

Enzymes, the organic catalysts made by a living organism, make possible all the chemical changes which occur within the organism. Any deviation of metabolism is therefore the result of changed enzymatic activity. This changed metabolism is not likely to result from one enzymatic aberration but rather from a change in balance between the activities of various enzymes. We know that 2,4-D does induce many metabolic changes in plants and it would be highly desirable if we could interpret the action of this chemical in terms of enzyme chemistry.

Most enzymes consist of a non-protein portion, called the prosthetic group, and a protein part. The prosthetic group, which may be metallic or organic, is responsible for the activity of the enzyme, while the protein portion gives the enzyme its specificity. The chemical combination occurs between substrate atoms and the prosthetic group. Thus the prosthetic group of a dehydrogenase (an enzyme of respiration) is reduced or oxidized as it gains or loses hydrogen. The protein may serve to activate the substrate by a fleeting combination with it, if their molecular architecture is suitable.

A substance may change the activity of an

enzyme by direct action on the prosthetic group or on the protein portion. There may be a combination with the prosthetic group to give a more or less stable complex. The ability of the prosthetic group to combine with substrate atoms is thus decreased. Cyanides inhibit some enzyme reactions in this way. The growth regulator may have a molecular architecture similar to that of the substrate and be able to compete with the substrate for the protein portion of the complete enzyme. If the regulator-protein combination is stable the protein is masked and its ability to combine in transient fashion with the substrate to activate it will be lessened. Both enzyme and substrate may be blocked by different regulator molecules combining with each other. On the other hand an increase in enzymatic activity would result if the growth regulator facilitated the enzyme-substrate combination by first forming a substrate-regulator-enzyme complex. Substances which inhibit enzymatic reaction may do so by competing with the prosthetic group (or coenzyme) for the protein. For example, sulfa drugs owe their effectiveness against certain bacteria to the fact that they are very similar to the vitamin which serves as the prosthetic group in certain respiratory enzymes of the bacteria. The sulfa drug combines with the protein to give a unit with no catalytic action and the respiration and growth of the bacteria are depressed.

The activity of an enzyme lacking a prosthetic group, amylase for example, is thought to lie in the orientation of amino acids in the protein molecule. A growth regulator might conceivably disturb this orientation and alter the ability of the enzyme to function.

Some investigators have found that the application of 2,4-D results in an immediate increase of enzyme activity followed by a decrease. It is possible that small amounts of 2,4-D may act in the substrate-regulator-enzyme complex to speed activity. As the 2,4-D accumulates, less rapid but more extensive actions on the prosthetic group and on the enzyme protein might bring about inhibition. The effects of 2,4-D on the apparent activity of phosphorylase, amylase, catalase and peroxidase in Marquis wheat followed this pattern. The experiments are being reported in the journal "Plant Physiology".

In addition to direct action on the enzyme itself the growth regulator may alter the enzymatic activity in an indirect fashion. It may, for example, change the pH (acidity) and the degree of hydration of the substrate and so alter the activity of the enzyme. It has been shown that 2,4-D changes the amount of riboflavin, thiamin, nicotinic acid and adenine in these plants. Members of the vitamin B group constitute the prosthetic groups of various enzymes, for example the dehydrogenases. The protein content of a plant and the amino acid balance are also altered by 2,4-D. The effect of 2,4-D on the activity of some enzymes may thus be produced by increased or decreased vitamins and amino acids for prosthetic group or enzyme-protein synthesis.

The abundance of the end product of a reaction sequence may be influenced by blocking the sequence at some intermediate point or by removing such a block already present. For example in the sequence A (1) B (2) C if enzyme (1) were inactivated or the intermediate product B withdrawn by combination with an inactivator the production of C would be decreased and the apparent activity of enzyme (2) would be lowered. If such a situation already exists an activator might prevent this weakening side action. The rate of respiration of some plant parts is normally limited by the capacity of the phosphorylating system. Since low concentrations of 2,4-D increase respiration it may well be that the chemical affects this phosphorylative portion of the respiratory sequence.

It has been shown that dehydroascorbic acid activates plant amylase while ascorbic acid, riboflavin, thiamine and calcium pantothenate inactivate it. This latter group also inhibits proteolytic activity. Variations in ascorbic acid and in the vitamin B group have been obtained in 2,4-D treated plants. This suggests that the effect of 2,4-D on amylase and proteolytic enzymes may be produced through its influence on other metabolites.

Changed metabolism may be the result of stimulated side reactions which result in products, which in their increased concentration, cause the metabolic change. One such effect has been ascribed to poisonous coumarin derivatives, the production of which is stimulated by 2,4-D.

Growth of a plant is controlled by the hormone indoleacetic acid. This hormone is destroyed by an indoleacetic acid oxidase system in which two enzymes are involved, a flavoprotein which produces hydrogen peroxide and a peroxidase which uses the peroxide to oxidize the indoleacetic acid. The enzyme catalase and the peroxidase use the same substrate, hydrogen peroxide. It will be remembered that lethal dose of 2,4-D decrease catalase activity, thus more hydrogen peroxide is available to the peroxidase, more indoleacetic acid is inactivated, and growth slows. In cases where low concentrations of 2,4-D stimulate growth, the amount of catalase may be increased, as in the experiments of the author. This increased catalase competes with the peroxidase for the peroxide, less indoleacetic acid is inactivated and growth is increased.

Information available at the present time does not seem sufficient to support the thesis that 2,4-D has very much direct action on the enzyme but the indirect effects of 2,4-D are many and of very considerable physiological significance.

Two very good reviews of numerous aspects of the physiological aspects of growth regulators have appeared in the Annual Review of Plant Physiology, Vol. 3, 1952, one by Bonner and Bandurski "Studies on the physiology, pharmacology and biochemistry of auxins" and the second "Agricultural application of growth regulators and their physiological basis" by Van Overbeek.

The effect of 2,4-D on a number of plant enzymes and vitamins is given in the table appended.

It is obvious that the effect differs from plant to plant and also in the various organs of a given plant. This variation coupled with the fact . that a number of the results were obtained by culturing tissue in 2,4-D solutions, some by adding 2,4-D to homogenates of plant tissue and some by applying the chemical to the growing plant and testing plant tissue for enzyme activity at intervals after the application make it difficult to interpret the results. Some of the results show that a response may be reversed as time after the application increases. In spite of the difficulties of interpretation it is only by a continuation of such investigations that the picture of how 2,4-D brings about its effects will be obtained.

EFFECT OF 2,4-D ON PLANT ENZYMES

ENZYME	PLANT	DOSE	EFFECT	REFERENCE
Alpha-hydroxy acid oxidase	Castor bean		0	Hagen '49
Amylase, alpha-	Virus tumor tissue	100 ppm in vitro	0	Brakke '52
Amylase	Bean stem slices	10 ppm culture	Increase	Gall '49
"	Kidney bean	50v/plant	Stem: increase Leaf: 0	Neely '50
" , beta	Wheat tops	5 and 500 ppm	2 day: increase 4 day: decrease	Wort '53
Ascorbic acid	Buckwheat	10v/plant 100 and 1000v/plant	Leaf, stem: increase Leaf: decrease Stem: increase	Wort '50
Ascorbic acid Oxidase	Barley seedlings	10-3 M	Decrease	Miller '51
"	Bean leaf	10-2 M	Decrease	Wagenknecht '51
Catalase	Tomato flower		Increase	Yakushkina '48
"	Castor bean		0	Hagen '49
"	Pea		Decrease	Goldacre '49
"	Artichoke		Decrease	Galston '51
"	Wheat	5 and 500 ppm	Increase	Wort '53
Glycolic acid Oxidase	Bean leaf		0	Wagenknecht '51
"	Barley	10-4 M	Decrease	Miller '51
Indoleacetic acid Oxidase	Pea		Increase	Goldacre '49
Invertase	Kidney bean	50v/plant	0	Neely '50
Lipase	Wheat germ	5.6 x 10-2 M	Decrease	Kvamme '49
"	" "	0,009 M	Decrease	Hagen '49
Nicotinic acid	Kidney bean	50v/plant	Leaf: decrease Stem: increase	Luecke'49
Pantothenic acid	" "	"	Leaf: increase Stem: decrease	Luecke'49
Pectin methoxylase	" "	"	Decrease	Neely '50
Peroxidase	Tomato		Flower: decrease Leaf: increase	Yakushkina '48
"	Kidney bean	5.7v/plant	Leaf protuberances: increase	Felber'48
"	Pea		0	Goldacre '51
"	Wheat	5 and 500ppm	Increase	Wort '53
Phosphate enzymes	Tomato		Increase	Ravazzoni'49
Phosphatase	Corn and cowpea seedlings	1.5 ppm	Root: increase	Olsen'50
"	Wheat	5 and 500 ppm	Decrease	Wort '53
Polypeptidase	Soybean		Leaf: decrease Root, Stem: increase	Freiberg'52
Polyphenoloxidase	Castor bean		Leaf: decrease Stem: increase Root: decrease	Rebstock'52
Thiamin	Kidney bean	50v/plant	Leaf: decrease Stem: increase	Luecke'49

LIFE HISTORY STUDIES OF WEEDS

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At present almost all weed investigational work is concerned with the application of control methods. The vast majority of weed investigations are conducted by persons whose principal interest is either the crop being invaded or the machines or herbicides used in control. Even though some botanists are conducting weed studies their efforts are often directed only to trials of control methods. Insufficient emphasis is being placed on studies of the weeds themselves. Recommendations for weed control are therefore not based on a thorough knowledge of the developmental history and ecological relations of individual weed species. This lack of botanical information concerning weeds not only places control recommendations on an unsound foundation but complicates the weed investigator's task in planning effective control experiments. For many of our most serious weeds vital details such as degree and causes of seed dormancy and the mode of pollination have not been studied.

Generally recommendations for control of weeds have been based on experiments in which control methods have been tried in a hit and miss manner, frequently with little knowledge of the stage at which the species is likely to respond best to the control influence. The weed worker has too often been in a position where he has been attempting to control a species by manipulation of the environment about plants of which he does not know critical details of the developmental history, and consequently relations with the environment can not be estimated. His position may be likened to that of the plant pathologist who is attempting to control a disease of which he has not yet ascertained the nature of the causal organism. Even when the knowledge accumulated by specialists concerning a species is considerable, the individual investigator has too frequently been unable to apply this to his problem because of his lack of specialization in weed work. Thus, although the taxonomy of most weeds has been worked out in very considerable detail, species are sometimes incorrectly identified in reports of weed studies (Frankton, 1949).

The control of our other field pests, insects and plant diseases, has been based on sounder foundations. Before control methods are attempted insects and organisms causing plant disease are studied for the purpose of obtaining fundamental information which is applicable to control. Entomologists are trained to "study the bug" and to apply control methods to their findings.

Botanical studies of weed species should logically have provided the basis for investigations in weed control. The work of taxonomists has added materially to our knowledge of weed species. However, the morphology, developmental history and ecological relations of many of our most troublesome species remain to be investigated. Since all control methods are based on manipulation of the environment to favor the growth of crop plants at the expense of weeds, an ecological understanding of each weed species is of some value. This is particularly true with respect to weeds which do not respond to methods of control already established. In the latter instance a new approach to control is indicated and this can only be intelligently planned when knowledge is available concerning the ecology of the species. Botanists have been associated too infrequently with studies of weed control. Instead agricultural engineers, herbicide specialists and agronomists have conducted these investigations. Their success has been outstanding with many species. However, methods of controlling other species are not yet adequate. Advancement in control methods has far surpassed our knowledge of the plant species upon which they are applied. In contrast to this situation in weed control, entomologists and plant pathologists have provided more copious assistance in establishing methods of controlling the other classes of pests based on fundamental studies of life history and ecology. Insects and plant disease organisms are evasive creatures which non-specialists have difficulty in understanding. The latter have not generally considered that they could cope with these organisms which give little warning of an attack and the appearance of which was often so unexpected that it resulted in devastation. Consequently professionals were enlisted to conduct fundamental studies. In contrast, weeds are comparatively stationary and have too often been considered to fall into a closely allied understandable group not requiring the attention of specialists. The result is that in Saskatchewan, for example, the full-time staff assigned to the study of agricultural pests numbers approximately 30 entomologists and 15 plant pathologists but no botanists are employed on a comparable basis.

Comprehensive studies of the developmental history and ecological relations of a few weed species have been reported (Stevens, 1924, 1943; Bakke, 1930; Kennedy and Crafts, 1931; Hanson and Rudd, 1933; Simonds, 1939). More frequently only certain phases of the life history of the species have been investigated by one investigator, and the remnants contributed by various workers have not been brought together. Too often the limited data conflict. The same portion of the life histories of several species have only rarely been compared by the same investigator, (Darlington, 1922; Chepil, 1946; Kummer, 1951). More or less complete life history reports of more weed species are necessary to the furtherance of control of many weeds. Physiological processes which are intimately linked with such studies have likewise not received the investigation they deserve.

Life history studies of plants have been given impetus recently through the efforts of the British Ecological Society. This organization began in 1941 to publish a series of reports on the life history of various species, some of them weeds, under the title "Biological flora of the British Isles" in THE JOURNAL OF ECOLOGY. Reports have been made concerning numerous indigenous and exotic species.

This Journal published an outline of suggestions of what should be included in a life history study, and later revised it (Brit. Ecol. Soc., 1941, 1947). More recently the Ecological Society of America has taken an interest in life history studies and in 1947 appointed a Committee on Ecological Life Histories, to look into the matter (Laurence, 1948). Under the sponsorship of this Committee a number of outlines have been prepared dealing with what life history studies of various plant groups should include (Pelton, 1951; Penfound, 1952; Duncan, 1952; Stevens and Rock, 1952; Curtis, 1952). The purpose of the following remarks is to indicate which stages of life history of weed species might be investigated to advantage, as far as possible application to control is concerned.

A study of the life history of a weed should include an investigation of its taxonomy and variation within the species. Frequently errors are being made in not recognizing variation between related species. For example, the species still being reported as Lepidium draba is really represented in Western Canada by three species (Groh, 1940; Coupland et al., 1950-1952; Corns and Frankton, 1952). The response of each of these to control measures is not necessarily or probably similar. Ecotypes within the species might account for other-

wise unexplainable variations in response to control measures. In this respect a study of the distribution within different habitats in a locality and of geographical distribution within the infested region is indicated. Associated with this investigation an evaluation should be made of the abundance of the species for the purpose of assessing the extent of the problem and of accumulating sufficient data to insure the support of control officers.

These initial field observations will suggest problems with respect to the developmental history of the plant. Knowledge of seed dormancy, longevity and viability under natural and controlled conditions will often be invaluable in explaining or anticipating the performance of a weed species. A study of the developmental history of a species is not complete without an investigation of details in the development of the seedling into a mature and reproducing plant. This study will involve consideration of the morphology of roots, stems, leaves and asexual and sexual reproductive structures, particularly as related to the effect of various environments on their development. Many of these phases of plant develoment may suggest some consideration in control.

Knowledge concerning the distribution of a species according to habitat and geographical range together with a detailed understanding of the developmental history of the species will form a basis for estimating the probably extent of the area which a recently introduced weed will become a problem. A study of the ecological relations will provide a basis for suggesting a control method which will modify the environment in a manner disadvantageous to the weed.

The methods involved in these studies of life histories must be developed in accord with the nature of the species under consideration. Annuals require different techniques from perennials, and introduced species may require a different approach from native species. Artificially infested plots have too frequently been used to study phases of life history and reaction to control. Particularly with perennials the results of such studies can only be applied when the weed species is known to be adapted to the environment of the plot area. At the University of Saskatchewan methods have been devised during the past four years for the study of introduced and native perennial species of weeds on infested farms within a large region. These studies have resulted in many findings which would not have been obtained from studies of artificially infested plots on the University Farm. The methods involved first include a farm to farm survey of the abundance and distribution of the species concerned on a municipal basis. This provides information concerning the range of habitats in which the weed occurs. Subsequently exclosures are established to exclude certain factors such as grazing animals and control methods. Permanent plots are located and the distribution of the weed is accurately mapped in the area in relation to competing vegetation. These areas are studied annually. Transplanting, germination studies, etc., provide additional information.

There is no reason why botanists cannot be enticed into the study of weed species if positions are made available for them. University training facilities are not being fully utilized and more students would enroll in botanical courses if positions were available. The paucity of botanists in the weed field is directly attributable to the lack of such positions and the unsound foundations on which weed control recommendations are based. Weed workers who recognize that there is considerable to be learned concerning each species and that each species is a separate problem will realize the shortcomings of the present plan. Their demands for fundamental knowledge of the organisms with which they are working will finally - let us hope soon - result in the establishment of botanical laboratories comparable to those entomological and plant pathological centres now so important to agricultural progress.

RESPIRATION RESPONSE OF WHEAT ROOT TIPS TO 2,4-DICHOROPHENOXYACETIC ACID, MALEIC HYDRAZIDE AND INDOLE ACETIC ACID.

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ABSTRACT

A wide range of concentrations of MH stimulated oxygen uptake of wheat roots. When an inhibitory concentration of MH was combined with inhibitory concentrations of 2,4-D or IAA the resulting inhibition in oxygen uptake was apparently a proportional rather than an additive effect of the two components.

Evidence from other sources indicate that MH is a growth inhibitor. Similarities between MH and 2,4-dinitrophenol as to physiological symptoms induced by them are:

(a) stimulation of oxygen uptake in the same range of concentrations in which cell division and growth are inhibited,

(b) effect of pH on oxygen uptake,

(c) an accumulation of sugars following treatment.

It was proposed that by tautomerization a phenol-type of hydrozyl, similar to that which has been suggested as being the principle center of combination in DNP, might be produced on MH. The data obtained by the authors and by other investigators support the view that MH is a growth inhibitor which functions in a manner somewhat similar to DNP. Although the evidence for this seems fragmentary, it has the advantage of reconciling any conflicting data which have been reported, and encompassing them under one hypothesis which attempts to describe the action of MH in terms of known physiological reactions.

COMPARISON OF PRESENT METHODS OF APPLICATION

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Regina.

To introduce the subject under discussion this morning, I think it would be of interest to go back several years and take a look at some of the things that happened early in the development of the widespread use of 2,4-D in Canada and the United States.

We know that sprayers of various type have been used in this country, and in others, for applying numerous types of chemicals for many years. Dusters have also been used for years to apply certain chemicals in dry dust forms. Most of us have seen various types of sprayers and dusters used in orchards in "orchard" areas many years before the use of chemicals for weed control came to be used so commonly in the wheat and corn growing areas. Orchard operators, consider spraying at different times of the year to control various types of diseases and insects as essential and routine to their successful operation. I think that many farmers in the wheat and corn growing areas are now beginning to look upon the use of 2,4-D in the same light in

spite of the fact that they are much newer to the game.

The requirements of a modern sprayer are much different to those considered essential 10 years or more ago. The volume of water used in spraying did not use to be considered a problem which was very serious. Orchards, vineyards and row crop were the main object of use for these Agricultural chemicals. Generally speaking, these areas consisted of comparatively limited acreage and were mostly situated in areas where there was an ample supply of water. Up to 300 gallons per acre was a common and accepted quantity to use on many of these spraying operations. When the spraying business moved out to the drier areas of the Great Plains in the United States and the Prairies of Western Canada this factor became of vital and paramount importance. Here we had an area where crops were grown on extensive acreages and where water was relatively scarce and rainfall generally light.

It was to satisfactorily supply the needs of this area that the low volume sprayer was developed.

Different types of spraying operations require different types of equipment. Orchard spraying uses a drenching or wetting spray which must be carried through heavy foliage to considerable height above ground. This can be accomplished by using long pipes on spray nozzles but is most commonly done by high pressures and large volumes of liquid which is carried onto foliage by this force. Some types of equipment employ an air blast to accomplish this object. Spraying in gardens or field crops does not require this type of equipment. This is done in small gardens by a great variety of hand sprayers and in large gardens or field crops by sprayers employing nozzles which direct the spray downward on the crop. In the corn belt, high clearance self-propelled sprayers are employed quite extensively. This is a good example of a special piece of spraying equipment developed to do a special job.

The simplest type of spraying equipment and one which many of us have used or seen being used is a common 2 or 3 gallon sprinkling can. I am sure that many of you have used this around your homes and gardens.to apply such chemicals as Paris Green or Bordeaux mixture. This sprayer will use more water per acre than any other and will also take more time to cover a given area. It has the saving grace of being cheap and nothing can go wrong with it. This type of sprayer will still be used by home owners for a long time to apply certain types of chemicals.

Another simple and low cost sprayer which is in widespread use is the so called knapsack sprayer with which I am sure you are all familiar. It is widely used by gardeners and home owners. This is a high volume low pressure sprayer which has several variations for creating pressure, all of which are mechanical. It is an ideal piece of equipment for spot treatment of small areas and around homes and gardens. The cost is low and the volume of liquid used is of little consequence since it is used on restricted areas. The slowness of application is also of little consequence for the same reason.

When we get into fields which cover larger areas such as orchards and large gardens, time becomes an important factor and larger sprayers have been designed for this purpose. These sprayers are powered by gasoline engines and utilize pumps which will give large volumes of water at high pressures. Some of these sprayers employ different types of application attachments which may be attached to the same machine. These attachments consist of rigid booms and nozzles on long pipes or poles which enable the operator to reach high trees and bushes. Other newer types employ a high velocity air blast to force the chemical where it is required. Equipment of this type is fairly costly.

Before the use of 2,4-D on grain crops came into widespread and common use, the di-nitro sprays were starting to be used in some areas for the control of certain weeds in grain and flax on fairly large acreages. This chemical required large volumes of water for satisfactory use and this proved to be one of the limiting factors in its general acceptance as a regular farm practice. The cost of the chemical was also pretty high. However the use of the di-nitro did create widespread interest in the use of selective chemicals for weed control in grain crops. Large sprayers for field use were offered to apply these di-nitro sprays and they were the fore-runners of our modern low volume field sprayers.

2,4-D first created public interest as a selective herbicide by its ability to eliminate dandelions from lawns in a very spectacular manner. It did no harm to the grass and was very easy to apply. Experimenters and manufacturers were applying this principle to crops of various kinds and found that certain weeds could be controlled in resistant crops with very minute quantities of the new chemical. Demonstrations all over the grain and corn belts of the United States and Canada in 1946 proved so convincing that spraying crops for weed control was hailed as a new era in farming and the biggest agricultural chemical boom in our history was on. By 1950 it was conservatively estimated that over 13 million acres of crop was sprayed in Western Canada and over 11 million acres in the 14 North Central States for an estimated total of over 25 million acres.

The tremendous expansion in the use of this chemical from 1947 to the present was beset with several growing pains. When it was demonstrated that large volumes of water were not necessary to accomplish good weed control, farmers in the dry areas were quick to adopt the practice. This economical and efficient method of weed control created an ever increasing demand for the chemical and for equipment to apply it. Manufacturing of the chemical was away ahead of development of satisfactory equipment. Many chemical manufacturers found themselves with quantities of chemicals on their hands which they could not sell because there were not enough sprayers available to apply it. Some of them were forced into manufacturing sprayers to provide an outlet for their chemical product. The demand was for a low priced sprayer and the competition was keen. Some of these early sprayers which appeared on the market left considerable to be desired when they got operating in the field. Many small machine shops all over the country suddenly developed into sprayer manufacturers without knowing just what was required, from a durability point of view or from an operating stand point.

There were three types of sprayers tried out in 1947 in Western Canada. These were the boom sprayer with its many types and designs employing the low volume nozzle, the boomless type of equipment which atomized the liquid in a high velocity air blast which distributed the chemical in low volume over the crop where it settled by gravity; and a vaporizing type of machine which employed heat to break the liquid up into a fog or a very finely divided vapor.

This vaporizing type of machine proved entirely unsatisfactory for field spraying due to the difficulty of controlling the fog or mist.

It was a costly machine and has disappeared from the crop spraying field in Western Canada.

The boomless atomizer type of sprayer was used quite extensively in 1947 and 1948 in Western Canada for field spraying. In the hands of good operators it did an excellent job and many are still in use. However, they are high priced machines and are being displaced with lower priced equipment.

The boom sprayer with low volume nozzles is the sprayer most widely used. This type is available in many combinations and in quite a wide price range. It can be secured in a tractor mounted power take-off type to a complete unit mounted on a trailer and equipped with a small air cooled engine.

Operators in the field in the earlier years had considerable trouble with these machines. Poor constructions and light materials led to booms breaking and framework failures. Inadequate filters caused aggravating delays and resulted in incomplete spraying jobs in the field. Pump failures were common and the engines supplied were often too small for the job which required continuous operation over fairly long periods. Recent developments have overcome many of these early defects and a good job of applying the chemical uniformly can now be accomplished.

Another development which appeared on the scene was the boomless sprayer which employed one or more large nozzles or batteries of nozzles. These sprayers had a lot of features which appealed to farmers. They were relatively low in price, had no booms to break and the large outlets in the nozzles did away with the nozzle plugging problem. However the prevailing winds in Western Canada upset the spray pattern to such an extent that a satisfactory job of applying the chemical uniformly cannot be accomplished in their present form. As a result they are in a very limited use as field sprayers in this area. They can be used to good advantage for road-side work or spot treatments where uniformity of application is not so important a factor as in spraying field crops.

While the development of sprayers was going on the same process on a smaller scale was taking place on dusters. The early types of dusters ran into structural weaknesses. Difficulties were encountered with some dust formulations feeding properly which resulted in ununiform applications. These difficulties have now been largely overcome and the use of dust is increasing each year. While the dust is more expensive to apply, this is offset by the fact that the farmer does not have to bother hauling water. The present day duster gives a good uniform application.

In applying chemicals to large acreages it was only natural that the aeroplane would appear on the scene. Helicopters were also used, but seem to be on their way out except for special jobs. Originally, it was dust that was chiefly applied by aircraft due to the limited carrying capacity of the aircraft. Difficulties with uncontrolled drift from the dust led to difficulties which forced the aircraft to a liquid spray. Diesel fuel is now used almost exclusively as a carrier. Refinement in nozzles has reached a point where some operators claim they can do a complete job using as low as ½ to ¾ gallon per acre. Most of the aircraft spraying is done by means of a boom suspended below the aircraft. Some operators have brushes rotating at high speed which throw the chemical out as a fine mist into the slip stream but this method does not appear to be as popular as the boom-type.

In application of chemical by aircraft the completeness of the job depends almost entirely on the skill and knowledge of the operator. The poor jobs done by the unskilled and careless operator makes it difficult for the good operator to sell his services to prospective customers. Generally speaking improved equipment and operating techniques have placed the aircraft spraying operators in a position where they can do a very satisfactory job of spraying where sufficient acreage is involved.

Some Railway companies have now devised rail-hauled equipment for weed control on their rights-of-way. This equipment is usually an adaptation of principles employed in the field sprays and redesigned to do a special job.

Modern farmers are quite mechanical minded and many of them have built very satisfactory sprayers themselves or they have altered and improved a commercial sprayer which they purchased. In most cases they have come up with a durable and efficient sprayer which is entirely adequate for their needs. I saw one self propelled sprayer with a 50 foot boom built entirely by a farmer. It was powered by a motor from a combine and did an excellent and fast job for the farmer. He felt that he could build a better sprayer for less money than any he could buy.

The most effective time to spray grain crops covers a fairly short period of time. For this reason most farmers in an area all want to be spraying about the same time. As a result the trend is for more and more farmers to own their own spraying or dusting equipment and for a decrease in custom work. Most farmers do not like to wait until the custom operator can get around to his farm.

The present trend appears to be towards the gradual increase in the use of dust in areas where it does an efficient job. There is also an decrease in custom work by ground equipment and farmers are getting their own spraying equipment. For field spraying there is a trend away from boomless sprayers of all types to the use of boom-sprayers. The increased operating efficiency of the aeroplane applicators has made this service quite acceptable to farmers and there is a trend to more widespread use of this method of weed control especially in the open plain areas of Canada and the United States where field acreages are extensive. Aeroplane application is also increasing in use on range lands.

Generally speaking, spraying and dusting equipment is now available which will do a very satisfactory job and stand up well to the work. Good equipment can also be found for special types of application where they may be required.

GENERAL DEVELOPMENT OF THE BOOMLESS SPRAYER

G.L. Shanks, University of Manitoba.

There are two distinct types of boomless sprayers. (1) those of the turbine variety and (2) those where a number of nozzles are closely combined into what may be described as a cluster. Both types have one feature in common--- namely, the width of swath covered is much greater than the clearance width of the machine in its operative position.

Turbine or fogging machines while never widely used for weed control have been in use much longer than machines with "cluster" type nozzles. So far as I can discover it was a central Manitoba farmer in 1949 who first tried to operate a nozzle type machine to produce results equivalent to that of a turbine. His machine was intended exclusively for grasshopper control. Learning of his idea we assisted somewhat in its development by selecting more suitable nozzles. This development is described in our Manitoba Circular published in late 1949 and revised in early 1950. A number of these units were

manufactured commercially in 1950 and used in grasshopper control These models were none too successful chiefly due to mechanical failure of the nozzle support as at that time it was felt that the nozzles required a spacing of four feet from the highest to the lowest.

In 1948 what is generally known as the Off Centre (O.C.) nozzle was developed at first in low gallonage size with rather small swath (6 ft. approximately) but later much larger giving swaths in excess of 25 feet. As a result we now have available a large variety of nozzles from which the desirable spray characteristics for almost any desired job may be selected.

What then are the advantages and disadvantages of the various types of boom and of boomless sprayers. The ordinary boom sprayer is now the standard of comparison for quality of work. This does not mean that it gives Uniform Distribution, the Most Effective Droplet Size or the Maximum of Spray Interception. These are difficult qualities to assess under field conditions hence when we use the boom sprayer as a standard of comparison for quality of work we say that in general results are satisfactory. However, boom sprayers are unwieldy, easily damaged, unsuited for high speed and above all the nozzles and filters are easily clogged and require cleaning even when the greatest care is taken. For roadsides, ditches and brush the boom sprayer is of little use.

On the other hand the boomless types of sprayer while simple to operate have lacked the, Control of Volume, Control of droplet size and Control of Wind Drift which are necessary if consistent results are to be attained. Their obvious advantages lie in their Low Cost, Mobility, Adaptibility to Roadside work and Freedom from nozzle clogging. However, with Nozzle of the Cluster, larger gallonage (per acre) seems inevitable. This is not the case however with the turbine machine.

Let us then consider the problem of the two general types of boomless sprayers and see how these requirements have been met to date.

In the turbine or fogging types of machine, represented by "The Buffalo Turbine", "The Tifa", the "C.C. Micron", "The Challenger" and "The Mistomatic" the distribution of the spray is achieved by dispersing the liquid in fine drops into the discharge of a fan or blower. The nozzle is adjustable for height and angle of discharge and as it is customary to direct the spray downwind, means for the rapid adjustment of nozzle direction is provided. This method of spray dispersal while assuring a wide swath and good control of droplet size does not assure uniform distribution and under windy conditions the rate of application is very variable. As very fine droplets may be used low gallonage gives adequate coverage. Little is known about the accuracy of coverage under field conditions. I know of only two turbine machines that have been used on Manitoba farms continuously since 1947 but these users apparently have been satisifed with results. About 50 turbine machines were purchased by Manitoba Municipalities during the recent grasshopper outbreak and some are being used for roadside brush control. The relatively high cost of these machines has always been a limiting factor in their use. It is of interest therefore to observe that this past season a machine on the turbine principle was manufactured and sold in Winnipeg at a price competitive with boom type sprayers. It is too soon to say how acceptable such a machine will prove but it is of ;interest as an alternative to the "cluster" type boomless sprayer.

These boomless sprayers have been produced with a variety of nozzle types. The main problems of this type of sprayer are, 1. To get adequate width of swath, 2. to get uniform coverage. and 3. to get satisfactorily low gallonage. These objectives are of course incompatible in some degree. With solid spraying as opposed to air stream carriage the distance spray can be projected is chiefly a matter of particle size. For the same reason one can throw a baseball further than a ping pong ball for example. But larger droplets mean fewer droplets and hence poorer coverage unless very large gallonages are employed. A drop of 100 microm diameter for example can be broken up into 1,000 drops of 10 micron size. What then is the most desirable size of drop and even if we know can we produce them? Concensus of opinion at present seems to favor a droplet size in the range of 30 to 100 microns diameter. Personally two years ago at the Milwaukee meeting I expressed a preference for 60 microns largely on the basis that this permitted a droplet falling at 4 millimeter intervals when 5 gallon (U.S.) per acre nozzles were used.

However, if we are to get acceptable width of swath from a boomless sprayer (nozzle type) much larger drops must be used. One simple solution of the problem is to use a nozzle or nozzles which produces a large assortment of drop sizes with the small drops falling close in and the larger drops farther from the machine. This effect can be achieved either by the offset (O.C.) nozzle already referred to or by a combination of tips (in a cluster) of varying characteristics chosen to give the desired overall effect. While this may sound simple those of you who are mathematically inclined will realize that with only three principal tips as shown in my experimental nozzle and allowing that only four gallonage sizes are required, then the permutations and combinations of 4 sizes in 3 places present a considerable chore for a series of laboratory.tests.

Well what is the status of "cluster" type nozzles at the close of 1952 season.

The two tip swivel type O.C. nozzle is not being used for crop spraying but only for roadside and brush spraying. We have made no tests on its accuracy.

The three tip O.C. nozzle was on sale in two gallonage rates this past season. We tested only the larger size and found placement none too accurate. A range of volume of 6 to 1 across the swath is a fair statement of its range of delivery.

The five tip O.C. nozzle while throwing some of its spray very high was more accurate with the probable range of 3 to 1. At a nozzle height of 3½ feet some of the spray goes 10 feet high, an obvious disadvantage on windy days.

The last type of "cluster" nozzles is one I have already indicated to be an experimental type. The tip sizes and combinations are an outgrowth of our 1949-50 tests. Laboratory tests of both the volume distribution and of spray pattern show this type of nozzle to be slightly better than the earlier types just discussed. A volume variation of 1½ to 1 may be expected and as will be seen from an examination of the inked pattern the size of the drops is very variable.

However laboratory and indoor tests cannot tell the whole story. I regard them chief as a guide in eliminating the more useless combinations. There is plenty of evidence that there is a very considerable tolerance in spraying rates and methods and that indifferent spraying techniques are not necessarily accompanied by poor results.

Hence when the tests and spray patterns just mentioned were completed we laid down a series of field size plots using the three types of "cluster" nozzles and a boom sprayer as a check.

In this test the average rate of application was 1.6 oz. acid (ester) equivalent per acre and even conceding that the swath variation did not exceed 4 to 1 this would mean rates varying from 0.8 to 3.2 oz. Even so, in only one plot was there any evidence of failure to kill the wild mustard with which the oat crop was infested. So if these tests proved anything it was the need for more precise information on dosage rates. As these tests were made at 5 M.P.H. with 5 M.P.H. tail wind they did not give any indication of how serious the effect of a cross wind would be. Other tests showed that an 8 M.P.H. cross wind could narrow the swath from 30 to 8 ft.

As already mentioned the present type of O.C. nozzle is swivelled. This adjustment presumably allows one to compensate for varying pressures and might also be used to counteract wind to some small degree. However I regard this feature of little value under field conditions as there is no practical method of obtaining the correct angle between the tips.

To conclude therefore it is my opinion that adequate full scale field tests of new types of spray application machinery should precede their marketing. Laboratory tests while valuable for control do not indicate with sufficient accuracy what practical end result can be expected.

A METHOD FOR THE TESTING AND COMPARISON OF BRODJET SPRAYERS.

Cady S. Corl, Hanson Chemical Equipment Company,

Beloit, Wisconsin.

A review of methods applicable to the testing of agricultural sprayers indicates that while individual nozzles of the flat spray and cone type have been tested by very satisfactory laboratory methods, (Ref: R.E. Larson, University of Minnesota, and G.L. Shanks, University of Manitoba) no satisfactory performance tests of multiple nozzle booms and/or Brodjet nozzles, either in the laboratory or field, have been reported or described heretofore.

In order to evaluate and compare Brodjet spray nozzles and assembled multiple nozzle boom sprayers, a test table of 1¼" corrugated aluminum sheets, 27 feet long and 16 feet wide was constructed. This was considered to be of sufficient length to obtain accurate data on one half of the spray swath width of the two-way Brodjet and the full width of most standard multiple nozzle sprayers.

The run-off (for a period of one minute) from each 1¼" trough is measured in graduated cylinders. These volumes are the points on all of the charts involved in this study.

Calculations will show that 32 cc per 1¼" strip for one minute represent a spray volume of ten gallons per acre at four miles per hour.

Any short comings (short swath and uneven distribution) of the 1952 off center sprayers are undoubtedly most noted in very sensitive crops and in the eradication of very resistant weeds. They performed with remarkable success generally for the more hardy crops and in the control of the less resistant weeds.

In certain areas there has been an insistent demand for a sprayer that would minimize the effect of gusty, almost ever present, wind conditions.

It was found in our work that the new Brodjet nozzle could be used in a horizontal position from 2 inches to 12 inches above the crop with a satisfactory distribution pattern over the entire swath, and with only a small reduction in the swath width, obtained in the normal vertical position of the sprayer. No other nozzle has been found to produce a satisfactory pattern in both the vertical and horizontal position.

In order to correlate laboratory performance data with field performance, this same set of nozzles were mounted on a tractor in a standard manner and tests were made as follows:

Conditions of Test:

1. Operation inside, without wind interference.
2. 36 inches above the crop for the vertical.
3. 12 inches above the crop for the horizontal.
4. 4 M.P.H. and 40 lbs. pressure.
5. Solution A;- a dye solution only, to show visually the spray swath and pattern.
6. Solution B;- a solution of Sodium Carbonate (Approx. 2# / gal.) to show actual chemical distribution.

In general the larger drops fall to the far end of the spray pattern providing greater resistance to pattern distortion than the smaller drops which fall to the inside of the spray swath. It appears that the swath width has been reduced about 20 per cent at 4 M.P.H. over the maximum swath obtained in a standing position. This tractor operation was repeated, using the Sodium Carbonate solution "B" under the same conditions and the sheet of paper dried and carefully folded twice with the treated side inside. Two inch strips of this sprayed paper were carefully cut with a paper cutter at each one foot interval and digested in distilled water and titrated with N/10 Hydrochloric acid.

By comparison with tests made in the laboratory or what could be called with no forward movement of the tractor, the swath at 4 M.P.H. has been reduced by about 20 per cent, resulting in an operating swath of about 50 to 54 feet in the vertical position and about 42 to 46 feet in the horizontal position. It is to be particularly noted in the graphs showing tests of actual chemical distribution that the pattern has been uniformly condensed by this amount and that the uniformity of the original swath has been maintained.

Proper evaluation and testing of any spraying method can only be accomplished by comparisons with other methods used for the same purpose. A search for laboratory tests and field operating data of multiple nozzle spraying methods was made and other than single nozzle tests, none were found. It was felt that inasmuch as the facilities were available, a comparative test of an entire multiple nozzle unit with currently used nozzles should be made. The following slides showing results obtained in testing a regular multiple nozzle boom sprayer using the test methods; show first, the uneveness of pattern under ideal conditions as specified in the operating direction.

To summarize: a method and the necessary equipment for laboratory and field testing of the Brodjet nozzle and the comparison with multiple nozzle boom sprayers has been described. A distribution patter of certain off center nozzles available during the 1952 season has been reported. A substantially improved Brodjet nozzle has been tested in both the laboratory and under field operating conditions in both the vertical plane and horizontal plane operations.

It has been shown that this new Brodjet nozzle produces uniform distribution of chemicals in both the vertical and horizontal positions and that their use in the horizontal position will undoubtedly broaden to a great extent the ability to spray during continuous, gusty wind conditions heretofore considered impractical with all types of sprayers.

By comparison it has been shown that the Brodjet nozzle produces a more uniform pattern than the conventional multiple nozzle boom, which apparently is subject to irregular and erractic distribution curves not previously appreciated. The new improved Brodjet nozzle is so designed that it can be used either in the vertical or horizontal position so as to produce considerably more uniform distribution of agricultural chemicals than has been heretofore possible. Continued research during the coming year will involve the thermal effect on spray patterns, droplet size and other factors.

AERIAL APPLICATION TECHNIQUES

R.E. Larson, University of Missouri.

In discussing the subject of aerial application techniques, I will endeavour to stick to the apparatus, or equipment, and methods of it use. Many of my remarks will concern new methods or equipment which I have observed in contacting various operators in the North Central region. The first item which comes to mind is the matter concerning the operation of the aerial application business. This business is not unlike any other in that in order to survive the managers have to be continually striving for improvement of equipment and technique. I have found that the operators are tending to stabilize to the extent that they have a fairly constant number of acres which they cover each year, more and more of which is repeat work for customers for whom they have obtained satisfactory results in previous years. In most cases this acreage includes a variety of applications in that it may be weed, brush, or sage brush control or pesticide application to cotton, potatoes, or sugar beets. By having such a variety of operations, the business is more stable than if it were to rely on just one of these fields for its revenue. Probably one of the most timely arguments for this varied program is brought out in reports of the small amount of weed control spraying in much of the winter wheat area this year. This is apparently due to the fact that they had very good growing conditions last fall and this, coupled with the dry weather that they had this summer, resulted in their having no weed control problems in their wheat. Those aerial applicators which were dependent upon this as their main or only source of revenue found themselves in dire straights; whereas other operators, who, though disappointed in the small amount of aerial weed work available, did have other work such as spraying on potatoes or beets which aided them in keeping their business going.

After the operator has improved his business set-up it has been necessary for him to consider the matter of keeping his airplanes in the air to carry out his operations. Along this line the next matter to consider is safety for the pilot. In visiting with the operators, I am sorry to report that only one operator brought this matter of safety into the conversation ahead of other things. In looking over his equipment the first thing he pointed out to me was the presence of the crash helmet hanging on the instrument panel of each plane. He went on to indicate that his planes did not leave the ground without his pilots wearing this crash helmet. I believe that more operators could well profit by taking such an attitude to aid in protecting their pilots.

A second safety item which should be brought to mind is that of the use of the safety belt. It is a common occurrence to see a pilot struggle with a safety harness and finally enlist aid in adjusting it. This problem has been attacked by the Personal Aircraft Research Center at Texas A & M College. They have designed a belt hook-up arrangement which should be much easier to put on or remove and thus make the pilot more inclined to use it.

Another safety problem which is being heard of more and more is that concerning the use of parathion. One company has attempted to overcome the hazards of the use of parathion by moving to the outside of the fuselage all parts of the spraying equipment which carry the chemical under pressure. The only part of the system located inside the fuselage containing liquid under pressure is the line leading to the pressure indicator. The hazard could be further reduced by the use of a belly tank which would make the system almost completely external. This would probably be suitable only on those planes which apply parathion exclusively, as most operators feel that the external tank produces too much drag such that in some cases the cure would be more hazardous than the possibility of the parathion poisoning.

The next item to be considered is that of the design of the plane itself. I believe that it is fairly well recognized that we do need a new plane designed especially for agricultural uses. Approaches to this problem have been made by three or four different companies or agencies, one result being the plane designated as the Ag-1 which is at present undergoing tests and improvements at Texas A & M College. This plane has at the present time been flown by approximately 600 pilots, each of which has made a report on the actions of the plane, these reports to be used as the basis for improvement. They are at present studying the distribution affected by this plane. Probably the biggest drawback about this plane is the probable initial cost which most operators seem to feel is too much to economically pay for itself in the aerial spraying business. It seems that the only alternative will be to modify some design of existing commercial planes at a lower cost. There are various projects under way at the present time which are attempting this very thing.

After considering the possibilities of the new plane design, the next place to look for a satisfactory agricultural airplane is in the modification of existing aircraft. At the present time many and varied are the attempts being made in this field. One such attempt at present is the redesign of the wings of a Stearman by the BE&PQ at their aircraft development center. This work is in cooperation with the Aerial Applicators Association. In an effort directed to reducing the flying speed and toward the elimination, if possible, of the effect on the spray distribution of the wing tip vortices, the ends of the wings have been squared off and the lift has been increased by lengthening the chord and increasing the thickness of the wings. Such attempts have been farily successful although they have necessitated increasing the size of the power plant over that which was originally designated for this plane. I believe it should be cautioned at this point that there are limits to such changes, those limits being controlled by the flying characteristics of the original design.

In any event all changes in existing aircraft or the design for new aircraft for agricultural purposes should keep in mind, or list as a prime consideration, the safety of the pilot. In some cases the aircraft has been indiscriminately changed by people who had no knowledge of the

aerodynamics concerned with the design of safe aircraft. I believe that many projects would do well to get qualified technicians to provide safer design and also to save money over their present cut and try methods.

I believe that we have covered sufficiently the matter of the aircraft itself so the next logical step is in considering the spray distribution system. Actually, there is not too much to report in the way of new equipment but I believe here I might make some observations which have come to my attention in looking over the various types now in use. An inspection of projects and equipment indicate that, in general, weed and brush control equipment is being changed to produce larger size droplets. In this case when I refer to large size drops, I am referring to those produced by such systems which have about 14 to 15 nozzles and which are operated under low pressure. These are in contrast to those systems which contain 20 to 25 nozzles and which operate at 30 or 40 pounds or more pressure. The larger droplets apparently reduce the amount of drift and seem to give better weed and brush control. I have reason to suspect that there is a limit to the coarseness of the drops which can be used economically. This is based on observations which are made on work we did last June in the spraying of oak. The system which we used operated at about 10 pounds pressure and distributed the liquid through 5 nozzles at the rate of 5 gallons per acre. The drops which are produced by this system were extremely large such that it was estimated that at least 75% of the spray was falling like raindrops with very little effect from the slipstream of the spray plane. In looking over the results of this spraying, I found evidence which seemed to indicate that these drops hit only one side of many of the trees requiring double flying to get full coverage. I have also had occasion to notice the same effect in plots which had been sprayed with the coarse droplets as produced by the 14 to 15 nozzle system which I mentioned previously. There was enough evidence to indicate there is a need for some investigation on this problem.

The next item to be considered is the shut-off valve. These valves at the present time seem to be one of three types; namely, the flapper type, the steam whistle type, and the individual spring loaded diaphragm at each nozzle. At the present time I believe the best is the flapper type, being the simplest and fairly consistent in giving a positive control over dripping. The whistle type valve is satisfactory only when the solution and equipment are free of any foreign material. The flapper valve has apparently overcome this difficulty, its big drawback being that it may need relining more often. This would depend on the lining material and also the nature of the material being sprayed. The set-up using the spring loaded diaphragm at each nozzle has a disadvantage in that it is very difficult to get a complete set at random in which all have the same shut off pressure. The amount of variance, while it may not be significant at high pressure, may become significant as the operating pressure is reduced. I believe that all three types should also have a master shut-off in the line from the pump to relieve the pressure in the boom and thus reduce the hazard of dripping and yet keep the boom full. Many operators have indicated they feel there is still a need for a perfect shut-off valve.

The next portion of this spraying operation to consider is the work of the ground crew. The first problem of theirs is that of flagging for the swaths, the purpose of which is to present an orderly method of flying that will give an even distribution of one flight in respect to the adjacent flight. There are various methods being used at the present time. The use of flag on a pole is probably most universally used, as it is well adapted to weed spraying and pesticide application in open areas. The use of met balloons is restricted to the spraying of brush and other situations where the flags are not suitable. Those using balloons for such work seem to find that they overcome the usual breakage problem by using one balloon inside another. After surveying the brush work in Oklahoma and Texas this fall, I feel that there will be a need for a new simple flagging device to overcome the thorns and rough terrain which will be encountered. The opinion is that in much of this area the use of the flags on the poles would end up as very haphazard application and only a rough distribution at best.

A second feature of the ground crew work is that of loading the plane. One of the biggest expense factors involved in aerial application can be the inefficient method of loading. The larger operators which are still in business have in the past recognized the need for quick and efficient loading operations. The smaller operators, who, in covering their contracted acreage each year, depend upon the farmers or whatever personnel they can pick up to act as ground crew, should keep their loading equipment simple but have it specialized as much as possible to overcome the inefficiencies of the personnel which will be using it. In any event it would be well for all operators to streamline their loading operations as an aid to reducing the number of delays which all of them encounter in applying herbicides. For most of this region the amount of time available with tolerable weather conditions is very small, such that the operation should be geared to function at top efficiency for short periods when the conditions are right.

I would like to summarize these remarks by saying there is still room for improvement of equipment and techniques in the aerial application business and that if these operators are to continue on a profitable basis they will have to give consideration to the factors of safety, business management, improvement of equipment and increasing the efficiency of ground operations. It is apparent that none of these factors can be disregarded in a successful spraying operation.

CHARACTERISTICS OF AIRPLANE SPRAY PATTERNS AT LOW FLIGHT ELEVATIONS.

Joseph C. Chamberlin, U.S. Department of Agriculture

The spray patterns produced by airplanes flying at low elevations have been studied jointly by the Bureau of Entomology and Plant Quarantine and the Bureau of Plant Industry, Soils, and Agricultural Engineering. The headquarters for the investigations are at Forest Grove, Oregon, but some of the field experiments were conducted in the extensive pea-growing area of eastern Oregon and Washington. A Stearman biplane powered by a 300-horsepower Lycoming engine and a constant-speed propeller was used chiefly in these studies.

The primary objects of the investigations were threefold - (1) to ascertain the characteristics of the usual spray pattern resulting from a symmetrical disposition of nozzles along an underwing boom; (2) to determine the nozzles or section of the boom from which the spray deposit for each zone of the covered swath came, and (3) to ascertain from these data optimum boom lengths and the arrangement of nozzles required to secure the most even and economical distribution pattern possible with reference to insecticidal require-

ments for any particular flight elevation and swath width.

With ground equipment operating at a very slow forward speed (up to 5 or 6 miles per hour) the discharge pattern of a serial array of spray nozzles depends primarily on the arrangement of nozzles and the amount of overlap from the individual nozzles. On the other hand, with aerial equipment, where forward speeds normally range from 60 to 100 miles per hour or more, aerodynamic forces are inevitably set up which modify and distort this symmetry. Thus, even though the spray is discharged in equal amounts from each of evenly spaced nozzles along an underwing boom, as it reaches the ground the spray has been so affected by the air currents generated by the passage of the airplane through the air (even though still air) as to vary greatly the deposit from foot to foot both across and along the line of flight. Consequently, some zones of the treated swath receive an amount of spray greatly in excess of requirements while other zones receive minimal or even subminimal amounts. Moreover, in striking contrast to the situation with ground equipment, the spray is spread laterally from the boom so as to cover a swath from 20 to 90 feet wider than the boom length, depending upon the height of flight and the fineness of the spray. Finally, sprays from aircraft are much more subject to drift as a result of surface winds than are those from ground equipment, and, furthermore, cannot be controlled with mechanical devices such as protective hoods. The effects of such air movements increase with elevation of flight as well as with the fineness of the spray.

The spray-dispersing air currents generated by the passage of the airplane itself constitute an expanding wake, which comprises primarily three whirling air streams, or vortices, one produced by the propeller slip stream and the other two by the wing tips. These latter currents carry the spray out well beyond the wing tips. The pattern laid down by the propeller slip stream is extremely erratic, areas of high and low deposits varying greatly and unpredictably both across and along the line of flight. A second effect of the propeller vortex is to shift much of the spray from that part of the boom lying from 1 to 3 or 4 feet right of center to a deposit zone left of center. In addition, the spray caught in this vortex is deposited more rapidly and completely than is that carried by the wing tip vortices. Beyond the zone affected by the propeller vortex and out to the margin of the swath, spray deposits tend to be zoned, but with areas of equal deposit variable in width and oscillating irregularly and non-rhythmically back and forth parallel to the line of flight.

Considerable improvement in mean spray-deposit rates across a treated swath may be expected from suitable asymmetrical nozzle arrangements, involving a massing of nozzles immediately to right of center, with a corresponding reduction left of center, the use of finer sprays inboard than outboard and with applications made at a moderate, rather than very low height of flight (at least 3 or 4 feet above the vegetation). Nevertheless, the aerodynamic factors are such that it seems certain that deposits will always vary greatly from foot to foot across and along the treated swath. In flights at low levels, therefore, rates of application must be keyed to the zones of minimal rather than of mean deposit. Such applications will necessarily give deposits in excess of requirements over much of the swath.

RAILWAY APPLICATION EQUIPMENT FOR WEED, GRASS AND BRUSH CONTROL BY USE OF CHEMICALS.

Hillard L. Smith, Dow Chemical Company.

On-track equipment for applying chemicals to the ballast section for weed and grass control has been in use in the U.S. for about 40 years. During this time much progress has been made with regard to equipment for applying the chemicals. The speaker has had the opportunity of observing the many changes and improvements that have been made since 1946.

Several railroads have devised spray equipment of their own, some of which is designed for applying the chemical to the ballast section as well as the right of way. The companies in the business of rendering weed control service to the railroads have been very active in this direction, with the result that phenomenal advances in spray equipment technology have taken place.

Many factors have influenced these advances in application equipment. Several new organic chemicals for weed, grass and brush control have been introduced during the last six years by the chemical companies which have played a vital part in need for better application equipment. Many of the railroads have become dieselized, making it unnecessary for the maintenance of a large number of water tanks along the system. Fewer water tanks present a problem with regard to a source of supply of water used in diluting the chemical concentrates for vegetation control Some chemicals are used in oil and do not require water. Hand and mechanical methods have been used extensively for vegetation control. However, between 1933 and 1950 wage rates rose more than 350%, thus making it much more economical to use chemicals applied by on-track equipment. Too, the impetus and publicity given weed, grass and brush control by agricultural authorities, power, highway and telephone company maintenance engineers, have had a part in influencing the types of equipment used for applying the chemicals. Manufacturers of spray nozzles have also played an important role in the improved methods of chemical application.

ROADBED OR BALLAST SECTION

The railroads and the railroad vegetation control service companies have concentrated, until the past five years, on the control of weeds in the ballast section. At first many roads desired to spray only a width of from 8 - 10 feet but now many railroads wish to treat 16 - 24 foot widths. Most roads spray the ballast section once a year while others may spray two or three times a year depending upon many factors, such as - length of growing season, type of vegetation, rainfall, soil type, chemical used, degree of control desired, etc.

RIGHT OF WAY

On-track equipment was used for brush and weed control in 1948 by two railroad; one developed their own spray equipment and the other cooperated with a service company in making the application. Since 1948 all of the service companies and some of the railroads have designed equipment for applying chemicals to the right of way for brush and weed control. Established grasses ordinarily are not affected by 2,4-D and 2,4,5-T and are left on the right of way to minimize soil erosion.

Several unique pieces of equipment have been designed to apply the hormone type herbicides to the right of way. The spray is applied at a speed variation of from 6 to 12 miles per hour. In most instances, an entire 200 foot right of way (usually the ballast section is not sprayed) may be sprayed in one operation. This represents about 20 acres per mile of track. Orchard type guns, fire and off-center nozzles are primarily used in applying the chemical. By using large orifices and relatively low pressure (50-150 psi) the chemical is literally rained on the vegetation at volumes often exceeding 200 gallons per acre, depending upon the height and density of the vegetation. Water is used in diluting the chemical, usually 1 gallon of chemical (low volatility esters containing 2 pounds 2,4-D and 2 pounds 2,4,5-T Acid equivalent per gallon) per 100 - 150 gallons of water. Application is made during the growing season. Most species of brush and weeds can be controlled with this mixture. One application per season is sufficient to control brush. A second application may be necessary the second or third year, depending upon the degree of control obtained the first year.

WOODEN TRESTLES AND BUILDINGS.

Vegetation control around wooden trestles, buildings, and other wooden structures and pole and cross-tie yards, is primarily for fire prevention measures. On-track equipment has been used for vegetation control around wooden trestles. Off-track equipment as well as hand application has been used for weed and grass control around these structures. Hand application is usually made with a dry product such as the borates.

More use should be made of the on-track equipment for applying chemicals now available for weed, grass and brush control around wooden trestles. Off-track equipment should be used for vegetation control around buildings, pole and cross-tie yards. At the present time much of this vegetation is cut by hand or mechanical methods.

APPLICATION OF NEW CHEMICALS

Based on past experiences, as new chemicals are introduced for vegetation control, the railroads and service organizations, no doubt, will provide the necessary equipment and develop new methods for making the applications.

Slide pictures of equipment were presented showing various types of railroad application equipment used in several sections of the country as well as some of the results obtained from using chemical vegetation control.

STRENGTHENING INDUSTRY-GOVERNMENT COOPERATION THROUGH THE NCWCC.

K.P. Buchholtz, University of Wisconsin.

We need make no issue of the fact that close cooperation between Industry and governmental workers will benefit all concerned. Most of us believe that the NCWCC will foster the close cooperation between industrial and governmental workers that we desire. If we did not believe this we would not attend these conferences year after year and we would not be here today. Our ideas of cooperation undoubtedly vary considerably and it would be useless to try and enumerate them all. Instead I shall attempt to cite a few ways in which the Conference has promoted cooperation in the past and how it may continue to do so in the future.

In a broad sense both of our groups have the same goal. This is to reduce the losses due to weeds and thereby to enable the farmer or the commercial concern to secure a more economical production. In a narrower sense, however, the objectives of industrial and governmental workers are different and the techniques used to gain the objectives are also likely to be different. We delude ourselves at times when we do not recognize these differences. It is my belief that more genuine cooperation can take place when both interests are fully aware of the objectives of the other and familiar with his problems. Otherwise we may assume that we are all one big happy family and then be irritated by techniques and attitudes that are not fully in agreement with our own.

A member of industry must be primarily concerned in merchandizing and adapting for use the products his company distributes. It is only reasonable to expect that he will support his companies offering and will give it the benefit of the doubt until it is clearly shown inferior for a particular use. A reasonable persistence is commendable for it may take some time to fully explore all the requirements for adaptation.

A governmental worker on the other hand must be more inclusive if he is to discharge his duty to the public properly. He should be familiar with the products of a number of companies and must be prepared to offer specific recommendations favoring one product or another as the evidence seems to indicate. This task is made difficult because it is almost impossible to be fully informed on everything he should know to make a satisfactory recommendation.

A well known axiom in education is that equal educational opportunities tend to promote understanding and consideration. It is especially fortunate that the NCWCC has continued to receive the support of industry as well as all groups of governmental workers. Through the program at the national meeting and the publications of the conference we have the opportunity to secure as factual and as complete information on weed control as there is available. Starting with this basic knowledge we can expect the atmosphere for cooperation and understanding to be favorable.

It is largely as a result of the activities of the conference that the research workers are no longer as positive as they were. Through their own experiences and the experiences of others shared at the conferences they know now that similar applications do not always give similar results. Regulatory and extension workers have found that progress comes more slowly than we desire at times and they have come to appreciate some of the basic problems for which we have as yet no answer. Industrial workers have found that materials with promising applications may have side effects such as drift, volatility, health hazards or disagreeable handling characteristics that seriously affect their practical use.

Perhaps it is even more important that the Conference provides the opportunity for all those interested in weed control to meet together to swap personal experiences and project plans for the future. The unknown is avoided by many people as being somehow too dangerous to experience needlessly. We all probably carry some taint of this psychological handicap for we often view as disreputable organizations or persons with whom we are not familiar. I can imagine no better way to overcome this quirk of human nature than to have representatives from all fields of weed control meet together for a few days. It soon becomes apparent that neither the industrial worker nor the governmental worker are trying to sabotage each others program. Our viewpoints may be different but a consideration of the background will show that viewpoints other than our own may indeed be possible and even probable.

It is the responsibility of the program committee to select subjects that will clarify our most controversial and most troublesome problems. It is the duty of industry in general to make certain that the program committee and the officers of the conference are aware of problems that seem important to you. Your problems may not seem important to a governmental worker who does not have to live with them and so they may not receive the consideration they deserve. I am a firm believer in the use of discussion and education as a means of achieving cooperation rather than the use of the steam roller. The latter technique may secure temporary acquiescense but it never fosters true cooperation and the team work we like to see.

The Conference has aided in settling some rather difficult problems. Some of you may recall the tussle we have had on recommendations concerning 2,4-D preparations, or the plea for packaging uniform concentrations of 2,4-D. At one time we disagreed widely on whether to use chemical concentration in the spray solutions or application per acre as the best methods of describing dosage. Problems such as these were not always solved at the time discussion was at its peak. Instead we carried back with us the pros and cons and developed our final decision afterwards. I believe it is significant that the problems which have had this detailed treatment have never again been brought up. We may not always have had complete accord but we have appreciated each others views and we have developed a working agreement. This is cooperation in its fullest sense and it is cooperation such as this that makes for real progress.

A moment ago I mentioned that equal opportunities for education were helpful in securing cooperation. I believe that educational opportunities can be developed even more by the industrial workers. At the time of introduction the industrial personnel usually know more about an herbicide than do those in governmental fields. The task of industry at this time is to convince both the governmental worker and the public in general of the value of a new product. Two approaches rather than one are most fruitful. The general public obviously cannot be supplied technical or detailed information. The governmental worker desires information of this type, however, for he must continually answer detailed questions and he must attempt to evaluate the product. A few concerns have made attempts to aid the governmental worker. They have assembled references to a particular product and have given data on methods of manufacture, solubilities, possible health hazards, plant responses and other facts useful for one who must talk about

it intelligently. This is appreciated and I am certain has helped to avoid blind acceptance or rejection. Attempting to sell or to recommend a material about which we know very little is one of the most frustrating experiences I can imagine. If we attempt to do so we probably don't make the sale and we probably don't make the recommendation either.

This organization has played a significant role in weed work during the past decade. It has achieved this role because of the cooperation it has enjoyed from its members. We cannot single out a particular group for praise for all have contributed. The NCWCC would not be the organization it is if industrial, extension, regulatory and research had not all contributed generously and cooperated freely. It is my hope that this attitude will continue. If it does the NCWCC will continue to be an organization of which we may be proud.

COMPLYING WITH GOVERNMENT REGULATIONS IN MERCHANDISING HERBICIDES.

P.M. Overholt, Canada Department of Agriculture, Ottawa.

In Canada, herbicides are among the pest control products controlled by the Pest Control Products Act, which, for short, we call the P.C.P. Act. This is a Federal Act administered by the Plant Products Division, Dominion Department of Agriculture. There is no comparable provincial legislation in any of the ten provinces of Canada.

Legislative control goes back to the Act of 1927, which was first applied in 1928. The Act was revised in 1939 to the form in which we have it now. Regulations under the Act are printed separately and are amended from time to time, as required. These amendments are simply by order of the Minister of Agriculture.

The first requirement is that herbicides sold or offered for sale in Canada be registered. Application is made on a special duplicate form which must disclose the name and percentage of each ingredient for the confidential information of the reviewing officers. The application must also show the brand name, and guarantee, and, of course, the signature and address of the applicant, and, in the case of applications from outside Canada, the signature and address of the resident Canadian agent who shares the responsibility of registration and of meeting other requirements.

Applications must be accompanied with three copies of the label or typescripts of the proposed label, including complete claims and directions for use. With new products being registered for the first time, acceptable evidence is required as to effectiveness and safety for use. The fee for an initial registration is $20.00 and for a renewal of registration, $5.00. The registration year corresponds to the Calendar year, and registration is required each year the product is sold or offered for sale. The Act does not apply to products for manufacturing purposes or to products which are for export only.

If approved, a registration number is assigned, which must be shown on the label, together with the brand name, the name and address of the registrant, the guarantee and statement of net contents, and, in the case of poisonous materials the poison markings and antidote. The inclusion of the name of the agent or distributor in the label is optional.

Other details for labelling are prescribed in the Regulations. The brand name, whenever practicable, must be descriptive of the product as to active substances, physical form and purpose, as for example "Liquid Herbicide contraining Butyl Ester of 2,4-D". The brand name may also contain the applicant's distinctive trade word mark. Products which deteriorate when frozen must be labelled "Protect from Frost", and combustibe materials, such as sodium chlorate must show the warning "May Cause Fire". Guarantees for dry products are in terms of the percentage content by weight of the active substance, and of liquid concentrates, in terms of ounces or pounds of the active substance per Imperial gallon. Conversion of the smaller U.S. gallon to Imperial measure is an important change called for when labelling herbicides imported from the United States. The statement of net contents of fluid products, on containers of 16 to 160 fluid ounces must be both in terms of fluid ounces and of pints, quarts or gallons or fractions thereof, Imperial measure. For quantities over one gallon the statement is in terms of quarts or gallons (Imperial).

In considering applications for registration we are governed by the advice of our consultants in the Division of Botany, Science Service, who appraise the effectiveness of products under Canadian conditions for the purposes represented, and the suitability of the directions for use. This advice is based on the decisions arrived at at the most recent weed control conferences, Easter and Western Sections, and the reports of the Herbicide Committee and the Weed Classification Committee. Samples of products are not required in connection with registration except for certain materials on which a practical test is deemed necessary. The Regulations provide for such pre-registration tests in collaboration with the applicant. A section in the Act provides for cancellation of a registration if the product is later found to be of doubtful value.

Modifications of claims and directions for use are frequently necessary before applications can be approved. In fairness to applicants it must be said that the recommendation conveyed to them are as a rule accepted and applied in the amended labelling. As a consequence, there are no definite specifications written into the regulations affecting herbicides, and the aim is to keep these to the very minimum for effective control. In this regard the continued cooperation of registrants is essential.

The Act is enforced by the Inspection Service of the Plant Products Division. The Division has eight inspection districts throughout Canada and two chemical laborstories, one, at Ottawa and one at Calgary. Inspectors examine the labelling of herbicides found throughout the trade and take samples for official analysis. Reports of analyses are forwarded to the registrant and to government officials concerned. Failures to meet guarantees, and other irregularities, are investigated by inspectors who seek the cooperation of the trade in correcting discrepancies. Products may be detailed pending these adjustments, and, in the more serious cases, legal action may follow if this is necessary in securing compliance with the law.

Though somewhat apart from the legal aspects it might be of interest to note here the growth in the use of herbicides in Canada, as indicated by the number of products registered. Back in 1928, the first year of registration, there were only eleven herbicides registered. Registrations now number more than 230 yearly and comprise more than twenty herbicidal materials, but more than half the total are 2,4-D formulations. This year, applications have come from 63 registrants, of whom nine are United States firms. The importance of herbicides in Canada

is also emphasized by the reports of the Dominion Bureau of Statistics on the sale of pest control products in Canada, which have been issued yearly since 1947. The report for 1951 estimates the total invoice value of all pesticides used in Canada at $15,801,000 of which $6,926,000 is the estimated value of the herbicides alone.

COMPLYING WITH GOVERNMENT REGULATIONS IN MERCHANDISING HERBICIDES UNITED STATES

J.A. Noone, National Agricultural Chemicals Ass'n., Washington, D.C.

The problem of complying with government regulations in the marketing of herbicides in the U.S. is intensified by the fact that in addition to the federal law, there are many state laws directly affecting the distribution and sale of these products. A review shows that there are more laws and regulations governing the sale, and use of herbicides than is the case with regard to other pest control chemicals.

Some of these laws and regulations follow a uniform pattern and are to be found in many states while others are unique and are in effect in only one or two states.

The Federal Insecticide Fungicide and Rodenticide Act and similar state acts in approximately 25 states require that herbicides be registered with the U.S. Department of Agriculture or its state counterpart before they are offered for sale. The procedure for obtaining registration and the difficulties that may be encountered in connection with it are reviewed in another paper entitled "Problems in Registration of Herbicides" presented at another session of the Conference and printed elsewhere in these Proceedings.

Even before a product is developed to the point where it can be offered for commercial sale, it is subject to governmental control and regulation. The federal act and most state acts have provisions relating to the distribution of experimental samples. Both exempt shipments to federal and state agencies authorized by law to conduct research in the field of pest control chemicals from the requirements of the respective acts. However, before shipping experimental samples to other organizations or individuals doing research in this field, a permit must be obtained from the U.S. Department of Agriculture. Most of the state laws require that a similar permit be obtained from the respective states if there is any charge made for the material but not if it is supplied free of charge. To obtain such permits, information must be submitted to the proper federal or state officials identifying the material, outlining the proposed research program and supplying certain technical data. On August 15, 1952, the U.S. Department of Agriculture announced its intention of amending the regulations governing the issuance of these permits and the new regulations are expected to be put into effect in the near future. Indications are that the new regulations will be more detailed as to the conditions under which experimental samples may be shipped, require that more information and data be supplied by the manufacturer in his application for a permit and generally tighten the control over the distribution of experimental samples.

In addition to the basic pesticides acts which are in effect in 39 states, there are general state laws specifically controlling the sale, distribution and/or use of herbicides. Among the provisions directly affecting the distribution and sale of these products are the following:

1. A special license is required to sell hormone-type herbicides in Texas.
2. Texas and Louisiana require that records be kept of all sales of hormone-type herbicides and periodic reports submitted to the state.
3. The sale of dust formulations of 2,4-D is prohibited in a few states.
4. The sale of products containing a herbicide in combination with insecticides or fertilizers is prohibited in some states; in others, it is dependent upon special approval of the formulation by the experiment station or agricultural college.
5. The storage or transportation of hormone-type herbicides with seeds, fertilizers, insecticides or fungicides is prohibited in Texas.
6. Colorado and Arkansas require that a broad purple band be painted on all 2,4-D containers.

Much more restrictive legislation and regulation have been proposed. Some of these proposals would completely ban the sale or use of all hormone-type herbicides in a state.

It is our opinion that education of the users rather than restrictive legislation is the answer to practically all the problems which have arisen in the use of herbicides. While the occasional misuse of herbicides and other pest control chemicals receives great publicity and depicts these materials in a bad light before the public, the labor-saving, money-saving, day to day benefits from the use of herbicides far out-weigh the mishaps. Rather than deny the benefits of chemical weed control to broad segments of agriculture by legislation, efforts should be made to educate the comparatively few individuals who do not use herbicides properly.

The Agricultural Chemicals Industry has been and is sponsoring an educational program on the proper use of its products. The key-note of this campaign is the slogan "For best results and safe use - read the label". We feel that this simple statement holds the answer to most of the problem in this field.

We urge all of you individually and collectively to intensify your efforts in the field of education and invite you to join us in our program.

CONTROL OF VEGETATION ON ROADBEDS AND SIMILAR AREAS

D.W. Young and W.E. Loomis, Iowa Agricultural Experiment Station.

Temporary or semipermanent soil sterilization to eliminate all vegetation is desirable in many locations, but is particularly important on the ballasted area of railroad tracks. Plants growing on the track may cause a serious loss of traction; constitute an incovenience and hazard to operating personnel in switching areas; slow drying of the ties and rails, and are considered unsightly and evidence of poor housekeeping. Dead vegetation holds water and snow and increases the fire hazard, particularly around trestles and in National Forests or dry ranges. Decaying plants accelerate deterioration of ballast, ties and rails.

Roadbed vegetation has been controlled by hand weeding, burning, and, since the turn of the century by herbicides such as sodium arsenite, sodium chlorate, oils, and more recently by the

newer herbicides such as TCA and 2,4-D. Hand weeding cost up to $100.00 a mile when labor was $1.00 a day and is now completely out of the question. Burning costs $50.00 to $100.00 per mile, gives only temporary control, and may involve serious fire hazards and damage to cross-ties. Herbicides also have their drawbacks.

The present research program at Iowa State College was started in the spring of 1951 in cooperation with the Association of American Railroads and has involved collaboration with the Florida and Montana Agricultural Experiment Stations and various railroads and commercial organizations.

The available herbicides have been used at varying rates and in different combinations on some 1500 test areas. Table 1 shows the results of the use of various herbicides on the ballast area in 1951. Increased effectiveness is noted for the combined use of 40 pounds TCA sodium salt and 80 pounds of sodium chlorate over increased amounts of these chemicals used alone. Similar results were obtained in 1952.

Tests were undertaken to ascertain the optimum amount of TCA and sodium chlorate to use in a herbicidal mixture. The TCA was varied from 20 to 60 pounds and the chlorate from 80 to 200 pounds per acre. The results showed little advantage from increasing the rate of sodium chlorate above 80 pounds. In several tests 40 pounds of TCA appeared to be the minimum effective rate. We have indications that two treatments of TCA 40 - chlorate 80 are more effective on resistant vegetation than increased rates at a single time.

In 1951 an experiment was started to study the cumulative effects of repeated treatments and their carry-over as soil sterilants. Table 2, Column one, shows that CMU and Borascu were the only chemicals that persisted for more than one year. From our studies it does not appear practical to control weeds for more than one season with one treatment. Chemical treatments may reduce weed populations and subsequent treatments may be less expensive than the first, but leaching of chemicals from the soil combined with reinfestation of weeds usually will make repeat treatments more economical than the use of excessive rates of existing chemicals to obtain prolonged sterilication.

Table 1.
Effect of several chemicals on roadbed vegetation.

Chemicals, lbs/A, 5/4/51	% Control, 10/15/51
TCA 80	50
Chlorate 320	72
TCA 40, Chlorate 80	80
CMU 30	85
CMU 10, Chlorate 80	88
CMU 10, TCA 40	88
Borascu 3200	85

Table 2. Effect of repeated treatments.

Chemical, lbs/A	% Control, 10/1/52	
	Tr. 1951 only	Tr. 1951 and '52
TCA 80	7	47
Chlorate 320	8	72
TCA 40, Chlorate 80	23	82
CMU 10, TCA 40	35	83
CMU 10, Chlorate 80	40	95
Borascu 3200	62	85
CMU 30	67	85

CMU has been extensively tested. It is a slow acting herbicide which is effective on perennial grasses in Iowa. Rates up to 80 pounds per acre showed little effect on roses and only limited effect on wild morning glory and horsetail. Rates of 20 pounds per acre have given excellent control of quack grass and smooth brome grass in Iowa and Montana. Ten pounds of CMU in combination with 80 pounds of sodium chlorate or 40 pounds of TCA has given as effective control as 20 pounds of CMU used alone (Table 3) on most plants in Iowa but was not effective on Bermuda grass in Florida. The addition of 2 pounds per acre of 2,4-D, DNOSBP and 10 gallons of oil to CMU has not increased the beneficial effect of CMU when they were applied together. At present CMU is expensive and difficult to keep in a sprayable suspension, but merits further testing.

Several experiments have been conducted to ascertain the most effective date of application of herbicides, using the two most promising combinations of chemicals tested in 1951 for perennial grass control. Spray dates in one test were November 9, 1951, April 18 and May 29, 1952. The chemicals used were TCA, 40 - chlorate, 80 and CMU, 10 - chlorate 80 pounds per acre. The plots consisted of nearly pure stands of quack and brome grass.

At each spray date the CMU - chlorate mixture gave slightly better control of perennial grasses than the TCA - chlorate, Table 4. The CMU - chlorate plots were decidedly more effective in resisting reinfestation by annual grasses and weeds. Of the three spray dates, April appeared to be slightly more effective. The CMU - chlorate spray applied in April and May tended to hold the track free from weeds during the season, while the November spraying showed considerable reinfestation of annuals toward the end of the following year. Although reinfestation with annuals was more rapid with the TCA - chlorate spray, follow-up treatments with oils etc. could have been used at a total cost below that of the CMU - chlorate.

Table 3. Effect of additives with CMU.

Chemical, lbs/A, 6/11/52	% Control, 10/15/52
CMU 10	73
CMU 10, TCA 40	88
CMU 10, Chlorate 80	86
CMU 10, oil 10 gal	70
CMU,10, 2,4-D 2	77
CMU 10, DN 2	67
CMU 20	88
CMU 40	95

Table 4. Effect of date of application.

Date of application	Chemical and lbs/A		
	TCA 40, Chlorate 80	CMU 10, Chlorate 80	
	% Control, 10/1/52		Av.
11/9/51	71	77	74
4/18/52	80	91	85
5/29/52	76	89	72
Average	76	86	

Use of Sodium Arsenite

Arsenic trioxide pellets have been tried as a safe way to use arsenic with essentially no effect in either 1951 or 1952. Sodium arsenite was tested in 1952 at the request of railroads that have been using this chemical. Arsenic was applied in July, a date which was too late for the most effective action of

TCA - chlorate, at the rate of 160 and 640 pounds per acre of arsenic trioxide equivalent. Both knock down and seasonal control were good with the heavier rate of arsenic, Table 5. Later tests have been undertaken to test this chemical further. Preliminary results suggest that arsenite may compete on a cost basis where the sometime serious stock losses attending its use can be avoided, and where leaching and fixation by carbonates are not serious.

Mixed vegetation growing on a silt loam soil was sprayed with 320 pounds of sodium arsenite per acre. Small plots were selected and leached with varying amounts of water immediately after treatment with the arsenite. Toxic effects on the vegetation were inversely proportional to the amount of leaching. Plots that were not leached gave rapid knock-down and effective kill of the vegetation present. Plots leached with more than six inches of water showed no effect on the vegetation. Plots that received less than six inches of water showed intermediate effects, Table 6. Leaching was done slowly and little or no run-off occurred. This susceptibility to leaching may limit the use of sodium arsenite in humid areas, and its reaction with carbonates reduce its effectiveness on limestone ballast or high lime soils.

Table 5. Mid-season herbicide

Chemical, lbs/A, 7/2/52	% Control, 10/1/52
Sodium arsenite 160	67
Sodium arsenite 640	93
TCA 30, chlorate 100	67
CMU 10, chlorate 100	88

Table 6. Leaching of sodium arsenite (1)

Water applied	% Control
0	100
1"	92
3"	70
6"	0

(1) 320 lbs Sodium arsenite/A

Drift and Volatility of 2,4-D under Field Conditions.

Volatile and low volatile esters of 2,4-D were applied to vegetation at 2, 6 and 10 pounds per acre in 60 gallons of oil or water carriers. Tomato plants were placed 20 feet from the edge of the sprayed area to determine drift and volatility effects. Wind velocities on test days were between 5 and 6 miles per hour.

The spray was released 3 feet above the ground at a pressure of 30 psi. In each of three tests drift was increased when oil was used as the carrier. In only one case of the 2 and 6 pound rates was 2,4-D effect noticed. This was on the downwind side with the volatile ester at 2 pounds and the low volatile ester at 6 pounds per acre in oil. At the 10 pound rate in one test both esters in oil affected the tomatoes on the downwind side. There was, however, no effect when water was used as the carrier. In another test at the 10 pound rate the low volatile ester in water affected only the tomatoes on the downwind side, while the low volatile ester in oil and the volatile ester in both oil and water affected the tomatoes on both sides of the treated areas. Before the end of the season the affected tomatoes recovered enough to set fruit. Willows and wild grapes were affected by 2,4-D in the railroad right-of-way but no injury was noticed on a soybean field 50 feet from the treated areas. Weed control from the two esters at the 3 rates was equal. However, where the heavy oil was used as a carrier for 2,4-D there was good control of annual grasses and severe effects on some perennial grasses.

In an extension of these experiments, 2,4-D was applied to a main line of the C & NW to study the effects of heavy traffic in picking up and scattering dry residues of 2,4-D. Tomato plants set on the right of way before spraying with 10 pounds of low and high volatile esters were injured by drift when oil was used as a carrier, but not when water was used. Plants placed near the track after spraying were not injured either by volatility or dusting out.

These results suggest that drift may be more important than volatility in 2,4-D damage and that dangers in the proper use of the compound need not be great. General experience with cotton, grapes and other susceptible crops does not support such a conclusion, however. It is suggested that 2,4-D be avoided when other chemicals can be used, that the water soluble salts be used, and that heavy rates be avoided. One to two pounds an acre may actually be more effective than a heavier dose.

The Use of Oils as Herbicides

Experiments conducted last season showed that diesel oil could be fortified with dinitros and pentachlorophenols to produce effective contact weed killers. This year a number of experiments were conducted to determine the factors in oils responsible for phytotoxicity and the number of times contact weed killers would have to be used to maintain a moderately clean ballast area. One to three treatments were made with six oils. In general two sprays with the more effective oils gave satisfactory control of annual weeds and helped hold the perennials in check. The better oils contained about 50 percent of aromatics and olefins and had boiling points between 500 and 700°F., Table 7. Oils with reduced aromatic content or reduced boiling points were less effective. The oils were used at rates of 60 gallons per acre and could be applied for approximately the same cost as burning, with the advantage of no fire damage and some preservative value for ties and rails. From a weed killing standpoint, oil sprays are easy to apply, and they offer no hazards to adjoining crops. The special value of oils probably lies in retreatments after perennials have been removed by other chemicals.

A mile of track was sprayed in May of 1952 with a mixture of TCA, 30 Chlorate, 100 and retreated in August with 60 gallons per acre of a heavy oil high in aromatic content. The two treatments gave satisfactory control of weeds for the season at a chemical cost of about $50 per mile. The latter spray was especially useful in the control of annuals such as ragweed, crab grass, and foxtail.

Table 7. Effectiveness of various oils.

Oil	Treatments	% Control, 9/15/52
Boiling range 500 - 700°F,	1	18
aromatics 50%	2	75
	3	87
Boiling range 380 - 600°F,	1	0
aromatics 57%	2	40
	3	47
Boiling range 400 - 600°F,	1	0
aromatics 15%	2	8
	3	8

Summary

In summary of a two year study, applications of 40 pounds of TCA sodium salt and 80 pounds of sodium chlorate per acre have given generally good control of quack grass, smooth brome grass and other miscellaneous weeds. Results with this mixture have been as good as with 400 pounds of sodium chlorate used alone and better than with 100 pounds of TCA sodium salt alone. Early applications, just as the perennial grasses appear in the spring, have given better results than late spring, and mid or late summer applications may give poor control. After the perennials are removed, periodic treatments with 60 gallons per acre of oil containing 50 percent aromatics and olefins and having a final boiling point of 700° have controlled reinfestation with annual broad leaved and grassy weeds. Fortifying the oil with 2 pounds of 2,4-D per acre may increase the value of the oil spray, especially in reducing stands of horsetail and other resistant weeds. Adding 2,4-D is feasible when there is no danger of drift to susceptible crops.

In Iowa an April or May treatment with TCA - Chlorate combined with an August application of oil has been the most practical first year treatment of several hundred tested. In Montana and Florida comparable results have been obtained, except that two TCA - Chlorate sprays may be required to eradicate Bermuda grass and three or more for nut grass.

THE ROLE OF THE FARM PRESS IN BETTER WEED CONTROL

Wallace D. Inman, Capper's Farmer, Topeka, Kansas.

The role of the agricultural press in weed control is as old as the press itself. It is a role of service---to farmers, research men, extension men, enforcement men and the industry.

It is an important role because weed control is vital to adequate food production for our growing population.

The farm press is uniquely equipped to further weed control work by reason of their staff of editor specialists whose background of information in their own fields equals that of any group of specialists anywhere in the world. These men with their background of information, plus their ability to translate the scientists knowledge into the farmer's own language, have earned the farmers understanding and faith.

That farmers want and appreciate this information is proven by the fact they pay for it and write in to ask for it. As an example, Capper's Farmer has received requests for, and issued, as many as 88,000 mimeographed leaflets on farming practises in one month. Another farm magazine rounded up a lot of weed control information, received requests for and gave away 65,000 of these booklets in a few weeks.

Farmers of today are alert, progressive and anxious to get new ideas. This pressure plus the help of the farm press in reporting of farmer's own ideas has speeded up research and sales. Sprayers are a good example. Much sprayer development occurred on farms and was reported in farm magazines. Now, among Capper's Farmer's 1,350,000 subscribers are owners of almost a quarter-million sprayers. These readers annually buy about 30,000 more sprayers (field sprayers). This potential would be impossible without editorial help---stories on sprayers and spraying---in the magazine---. And the national state and regional farm press reaches all 5.3 million U.S. farmers, several times over.

Two surveys by the Statistical Laboratory of Iowa State College help prove where farmers go when they want information on farming practices. In the latest survey, when asked where they went for information on weed and insect control, more than 60 percent of the farmers said they read the farm magazines they had in their homes.

In the earlier survey, asked where they went for information on growing corn and other field crops---which would include weed control information and advice---46 percent of the farmers said they got information from specific farm papers they had in their homes; 21 percent from radio; 7 percent from extension workers and bulletins; 14 percent from commercial sources and 16 percent from other sources.

For information on the care and use of farm machinery---which would include spray equipment or dusting equipment---44 percent of the farmers named the farm press; 9 percent radio; 2.5 percent extension workers and bulletins and a little over half mentioned commercial sources, instruction manuals and the like.

While it is true the farm press gets much help and advice and many suggestions, from extension, these figures show that in addition to being of vital importance to farmers in the daily operation of their enterprise, the farm press also plays a vital role and invites use by research, regulatory and extension personnel as well as by industry.

And speaking for my colleagues among the agricultural editors, we intend to do everything we can to see that the role of the press grows in service to all.

SUMMARY OF PANEL DISCUSSION:

"Where Are We Headed With Aerial Application?"

Chairman: John Burke, Aerial Applicators Association
F.W. Bone, Department of Transport, Civil Aviation, Winnipeg.
R.E. Larson, University of Missouri, Columbia, Mo.
J.C. Chamberlain, U.S. Department of Agriculture, Forest Grove, Oregon.

1. The agricultural aviation people need help of a technical nature on all phases of their activities, i.e. engineering, chemical, agronomic and economic.

2. Not all trouble laid to aerial applicators is actually a result of their activities. In one area of eight claims against aerial applicators, five were found on investigation to have resulted from ground application.

3. Unethical and careless operators are being weeded out as a result of competition.

4. 300 accidents with 51 fatalities in 90 days is evidence that further study is needed of operational hazards.

5. There is need for aircraft design research. The Ag.1 is not performing to the satisfaction of many operators.

6. A better system of speedy dissemination of information relative to pest out-breaks where aircraft services are needed would be desirable.

7. Proper regulation to protect all concerned should be set up at the State level.

SOME OBSERVATIONS ON POPULATION DYNAMICS OF SECONDARY WOODY VEGETATION.

H.L. Hanson, University of Minnesota.

1. Population dynamics and the problems of brush control.

Most plant workers recognize that the vegetation of the field and forest is in a constant state of flux. Competition between individuals of the same and of different growth habits, variations in any of the numerous elements of the environment, the cycle of life processes from establishment to maturity and decadence, these and other forces result in an interplay of vegatational responses to environmental changes. When the various activities of man's initiation, as well as the often severely disruptive influences of insects, disease, fire and other natural factors are added to this picture, vegetational changes of great significance usually result. The plant ecologist deals with these various responses of vegetation to environment, and like other scientific workers has often formalized his knowledge and clothed his lack of knowledge in an impressive terminology.

The past half a dozen years or so has seen a tremendous surge of interest and investigation into the possibilities of controlling undesirable plants by various chemicals applied in various ways. A very significant part of this picture has been the interest in controlling unwanted woody plants commonly lumped together under the term "brush". In a general way control measures can be classified as attempts to reduce the abundance of the brush or to change the composition of the vegetation along desired lines. The pasture and range improvement specialist is trying to induce an ecological succession from brush to grasses for the greater value they have for animal food, the highway maintenance man is interested in converting the brushy vegetation on his ditches and roadsides to lower growing plant forms in the interest of visibility and more economical maintenance, and the forester is often interested in encouraging the valuable coniferous species at the expense of the "weed trees" and brush. All these activities may be described as attempts to direct population dynamics along desired lines.

Unfortunately, fundamental knowledge of the processes involved in the response of brush to chemicals has lagged far behind the developments in the chemicals themselves. These brush species being of low or negative economic value have been given little or no study and investigation. Our knowledge is highly inadequate as to the nature of the regeneration processes themselves, the recovery potentials of the various brush species under different conditions and the details as to how and why brush invades areas.

The observations and data reported in this paper are an attempt to encourage and stimulate critical investigation of this virgin field of population dynamics of brush as related to problem of its control. Specifically this paper is a report of:

(1) an intensive, detailed series of records made over a five-year-period of the response of the secondary vegetation under a forest canopy of pine and hardwoods following the application of 2,4-D as a foliage spray,
(2) observations on the rate of invasion by various brush species into three pioneer areas.

It is recognized that these investigations cover only a very limited part of the processes involved in population changes and involve only a few species. However, it was hoped that the data collected and the methods used might contribute to the knowledge and suggest further work with other species.

11. Nature of the investigations and data collected.

Records of vegetational changes on spray plots.

The first part of this report deals with the response of the woody vegetation in a forest following spraying. The plots involved are located in a mixed pine-hardwood type in Itasca State Park, Minn. There is a scattering of virgin white and Norway pine over 200 years old with a sparse lower tree canopy composed largely of paper birch and quaking aspen. The secondary vegetation is an extremely heavy undergrowth of brush running from 25,000 to 30,000 stems per acre. Hazel makes up 80 to 90 per cent of this population with panicled dogwood, choke cherry, arrowwood, raspberry, blueberry, juneberry,and several other species present in scattered occurrence. Approximately 3,000 to 4,000 small white pine seedlings were present under the brush but none showed any evidence of being able to establish permanently in competition with the brush.

In July 1948 two plots each a tenth-acre in size with an additional border about 15 feet wide around them were sprayed using an ethyl ester of 2,4-D at the rate of 1½ pounds of acid in 40 gallons of water per acre. Two similar plots adjacent to those sprayed were set aside as controls. The original objective in spraying was to test the possibility of encouraging the establishment of the pine seedlings by killing the brush.

The condition of the vegetation of these plots before spraying, after spraying in 1948 or 1949, and on August, 1952, has been summarized in the form of curves showing population changes.

Observations of Brush Invasion on Pioneer Areas.

The second part of this report is a record of data taken and observations made on several areas on which no vegetation was present at known dates and which have been subjected to the processes of brush invasion for varying periods of time since then. The availability of three lakes in three different areas in northern Minnesota which at different times in the past had their water levels greatly reduced and former lake bottom exposed presented a unique opportunity for the study of the rate and nature of invations processes. The information relative to these areas is largely of a preliminary report nature. It is planned that further study will be made for the collection of data of a more detailed quantitative nature. A brief description of these areas follows:

1. East Rabbit Lake north of Crosby, Minnesota. This lake was lowered 30 feet in 1945 to expose iron ore deposits in its bed. It was reduced in size from 534 acres to a small shallow sump in the center. The surrounding area is largely forested with mixed oak, aspen, and birch types. Some Norway pine and jack pine are also present. Observations indicated the presence of a great variety of all the common brush species of the region with the possible exception of alder which seemed to be present in only rather limited abundance.

2. Bass Lake, north of the Echo Trail about 6 miles west of Ely, Minnesota. This lake had been partly drained in 1925 when the impounded water cut a trough thru the moraine serving as a natural dam. Water level dropped 52 feet and the lake was reduced in size from 494 to 250 acres. The lake lies in a deep trough in the rock outcrop hills characteristic of this region and is completely surrounded by a northern coniferous forest with mixtures of aspen, birch, and other minor species. Brush including predominantly hazel, alder and other species characteristic of the norther coniferous forest is present in moderate abundance.

3. Sunken Lake, in the Chippewa National Forest northwest of the Cut Foot Sioux Ranger Station. In 1915 this lake was lowered 17 feet and reduced in size from 90 to 62 acres when logging operations resulted in a washout of the narrow strip of till acting as a natural dam at the outlet. The surrounding forest is mixed pine-hardwood with some spruce and balsam fir also present. A great variety and abundance of brush is also present especially on the west side of the lake.

III. The Data
Spray Plots

Some of the information collected on the spray over a five year period have been summarized in the form of straight line curves showing various vegetational trends and responses. Special attention has been called to the response of hazel, raspberry and white pine seedlings. The hazel is of special interest because of its great abundance and its position as the number one problem species on upland areas in this region. Although raspberry was present in the sprayed areas in very limited numbers, data on this species were presented because of its special interest as a species quite tolerant of 2,4-D sprays. The data on natural reproduction of white pine were included because the objective of the spraying was to test the ability of this species to respond following the reduction by spraying of competition from the brush.

Pioneer Area Invasion

Surrounding the three lakes which have had their water levels lowered are strips of various widths which were formerly lake bottom. The previous shoreline for each lake was located and the area exposed by the recession of the water examined as to the vegetation now present. Lists of the relative abundance of the various trees and shrubs found follow.

Relative Abundance of Various Species of Woody Plants Found Invading Pioneer Areas

Area	Length of Invasion Period	Relative Abundance listed in decreasing order. Trees	Shrubs
East Rabbit Lake	7 years	balsam poplar quaking aspen	willows(abundant)
Bass Lake	27 years	quaking aspen paper birch Norway pine jack pine balsam fir	raspberry (abundant) willows(common) bush honeysuckle(sparse) snowberry(sparse) hazel(sparse) alder(sparse) round leaved dogwood(sparse)
Sunken Lake (east shore)	35 years	balsam poplar quaking aspen red oak jack pine	sand cherry (common) smooth sumac (common) choke cherry (sparse) wild rose (sparse) bush honeysuckle(sparse) juneberry (sparse) hazel(sparse)
Sunken Lake (west shore)	35 years	quaking aspen red oak balsam poplar paper birch jack pine red maple	raspberry (abundant) hazel(common) willow(sparse) snowberry (sparse) spiraea (sparse) red osier dogwood (sparse)

IV Discussion of the Data
Spray Plot Records

Several very distinct trends are evident in the curves depicting the five year population records.

1. The general effectiveness of the spraying in killing back the aerial stems of the brush population is evident from the pre-sray 1948 figures compared with the post-spray 1948 or 1949 figures.
2. The effectiveness of the spray on the hazel brush considered alone was even greater than its effectiveness on all brush species considered together.
3. A very few of the smallest size of hazel stems seemed to have escaped being killed back by the spray. This was very likely due to their position under the dense canopy of the taller stems sheltering them somewhat from the spray.
4. Raspberry which was not present on the quadrate before spraying invaded from nearby and built up a population of well over 20,000 stems per acre in the 5 year period.
5. The white pine seedlings were very favorably affected by the release from brush competition and increased from less than 2500 seedlings per acre to over 8500. No such increases occurred on the check plots.
6. The regrowth of hazel that has taken place during the five year period is in the form of sprouts from the root collar, sprouts from rhizones and recovery by adventitious buds

from aerial stems. Almost all of this is still less than three feet tall.

Pioneer Area Observations.

1. Various species of willows predominated in the initial stages of invasion. This was very likely true because of the initial wet condition of the areas. After seven years they still constituted the primary vegetation and no other shrubs were present. On one area they had been very greatly reduced in abundance after 27 years and on the 35 year old areas they had either entirely disappeared or were present in small numbers. Apparently considerably before 25 years from the time of invasion on an initially wet area the willows completely disappear except for small spots where moisture conditions continue to remain favorable to it.

2. Hazel brush seems to have a very slow rate of invasion on pioneer areas such as those examined. On the area available for invasion over a 25 year period only a small scattered population was present. On one of the 35 year old areas it was recorded as sparse and scattered and on the second 35 year old area it was found to be common but not abundant. Immediately adjacent to this area near the previous shore line of the lake an extremely heavy hazel population is present. There is therefore an abundant source from which invasion could have taken place.

3. Raspberry was the most common shrub on the 27 year old area and also on one of the 35 year old areas. On the more xeric habitat of the second 35 year old area it was not present at all on the plots. Apparently when the habitat is favorable, the native raspberries have a great invasion potential, but they have rather definite requirements as to soil and light conditions that limit their competitive ability. This is borne out by the records on the spray plot area also.

4. Alder was found to have invaded only on the new shorelines right next to the lakes or in a relatively few spots farther up where moisture conditions seemed to be more favorable. However, some of the alder which had constituted the fringe along the old shorelines was still present even after 35 years. This would seem to indicate that the inability of alder to invade the drier areas is the result of a seedbed requirement rather than its inability to live on such areas after establishment.

V General Conclusions.

1. The recovery potential of hazel is such that between 5 and 10 years following complete killing back of the aerial stems they will be replaced by a second stand of approximately the same density. This regrowth will be almost entirely from sprouts and suckers from the old root collars and rhizome systems.

2. Hazel brush has a very slow rate of initial invasion by a seedling invasion process. After 35 years on a favorable site and adjacent to a great abundance of established plants it had not yet invaded to a point where it would be called a problem in forest management.

3. Alder is limited in its ability to invade new areas by its requirement for a wet seedbed. Once established, however, it can exist on upland areas for 35 years or more.

4. Raspberry and the various species of willows seem to have the greatest potential invasion rate of any of the brush species observed. However, these species also have rather fixed site requirements which make them poor competitors with other species. Both the raspberries and the willows are highly intolerant of shade which may explain their inability to compete. In addition willow seems to have a wet seedbed requirement that limits its spread.

5. The relative importance of seedling regeneration and vegetative regeneration in accounting for the invasion ability of raspberry and willow is not definitely clear.

BRUSH CONTROL OF HARDWOODS FOR GRASS PRODUCTION

Harry M. Elwell, Bureau of Plant Industry, Oklahoma.

Shrubby brush of hardwood species has choked off production on millions of acres of range land in the southwest. Their severe competition for moisture, sunlight and plant food greatly reduces growth of the better forage plants and represents one of the greatest deterrants to range forage production. Droughts have been common in this area. When they occurred, overgrazing of forage and fire were common. This depressed grass production and has been largely responsible for the rapid expansion of brush over the once famous grasslands.

Brush control investigations on oaks and other hardwood species were started on the Red Plains Conservation Experiment Station at Guthrie, Oklahoma in 1935. The first work was done with hand tools, but since then various methods have been tried. Chemicals were introduced in these studies in 1945. These studies have now spread through field trial tests in Soil Conservation Districts to various parts of the state. This report evaluates the effectiveness of all of this work.

This research has been conducted by the Soil Conservation Service in cooperation with the Oklahoma Agricultural Experiment Station. Most effective cooperation was also given by chemical and meat processing companies, manufacturers and operators of spraying equipment, farmers, and the Flying Farmer's Research Foundation.

SPECIES OF HARDWOODS

The major species of hardwoods studied were those associated with the post oak-blackjack types of brush and small trees. The predominating species were blackjack (Querous marilandica Muench), post oak (Querous stellata Wang), white oak (Querous alba L), Dwarf Chinquapin (Querous prinoides Wild) and pin oak (Querous palustris Muench). Other hardwoods often intermingled with them were: hickory's (mostly Hicoria alba L Britton or Hicoria buckleyi Dur Sud), white and winged elms (Ulmus americana L and Ulmus alata Michx), Osage Orange (Toxylon poimiferum Rafn), black and honey locusts (Robinia pseudoacacia L and Gl enditsia triacanthos L), hackberry (C. Occidentalis crassifolia La M Gray), Chittan wood (Bumelia lanuginosa Michx Persoon), Western Crab Apple (Malus ioensis palmeri Rhed), willow (Salix nigra Marsh), cottonwood (Populus deltoides virginiana Cast Sud), Sassafras (Sassafras varifolium Sal Kun), Dogwood (Cornus asperifolia Mich), Redbud (Cercis canadensis L) and Persimmon (Diospyros virginiana L).

Along with this type of vegetation were also areas of small shrubs and brambles. They were composed of sumace (Rhus copallina L and glabra L), sand plum (Prunus angustifolia Marsh), buckbrush (Symphoricarpos orbiculatus), blackberry (Rubus spp.), wild rose (Rosa spp.) and greenbrier (Smilax spp.).

METHODS OF CONTROL

Methods of applying chemicals for brush

control were foliage sprays, basalbark and stump treatments. These methods have all given satisfactory results when used on brush within the limits for which each is best suited. It appears unlikely that any one method can be developed to operate satisfactorily under all conditions and types of brush. Before deciding the method to use on a given area, a survey should be made to determine the size and different kinds of species present. The various species and plants are not equally affected by chemicals. Therefore, a list of susceptibility of various species to herbicides will be helpful. This information can be obtained from the North Central Weed Control Research reports and from chemical companies.

Foliage Sprays

Foliage sprays have been applied at several locations on the oak types of brush. Applications were made with several kinds of motor-driven sprayers. The leaves, twigs and stems of all the plants were thoroghly wet with the soluation. The most effective and satisfactory time to spray was when plants were approaching full leaf size, while photosynthesis was active. Solutions of 200 to 300 gallons per acre have been effective. Pressures of 100 pounds or slightly less were most desirable.

Several air-blast sprayers were tested at the Red Plains Station. This type of equipment was useful in treating isolated and dense stands of woody plants. It was also possible to obtain good coverage with the air-blast machine and to use less spray solution than with the hydraulic types. This type of equipment, however, needs to be investigated further.

Selective Herbicides. The ester formulations have generally given the best control of brush in foliage treatments. The new formulations applied recently include esters of butoxy ethanol, the combination of propylene glycol butyl ether and alkylglycol. These low-volatile esters appeared to be more effective than the older types. However, in the earlier tests, using a large volume application on fully leafed brush, the isopropyl, butyl ethyl esters and also sodium and ammonium salts and amine formulations of 2,4-D and 2,4,5-T have killed oak brush (Table 1). These older preparations, however, often produced erratic results and required more retreatments. These plots were sprayed with a hydraulic sprayer until the foliage was wet with two pounds of acid in 100 gallons of water. Effective control of this oak brush was obtained from several of these treatments.

TABLE 1. EFFECT OF SELECTIVE HERBICIDES IN FOLIAGE SPRAYS ON OAK BRUSH

Guthrie, Oklahoma 1/

Kind of Chemical	Date and Treatment 2/ Sprayed	Retreated	Percent of Brush Remaining October 1952
Untreated(Check)	--	--	100.0
Salts of 2,4-D			
Sodium	April 1946	May 1947	34.2
Ammonium	July 1946	May 1947	26.1
Ammonium	May 1947	May 1948	5.5
Amines of 2,4-D			
Triethanol	April 1946	May 1947	77.5
Triethanol	May 1946	May 1947	25.6
Esters of 2,4-D			
Ethyl	June 1945	May 1947	8.4
Ethyl	April 1946	May 1947	26.8
Butyl	April 1946	May 1947	38.6
Butyl	May 1947	May 1948	7.7
Isopropyl	May 1947	May 1948	7.7
Isopropyl	July 1947	May 1948	3.0
Isopropyl	May 1947	May 1948	9.5
Esters of 2,4,5-T			
Isopropyl	May 1947	May 1948	1.4

1/ There was originally an average of 10,396 trees and shrubs per acre of the post-oak-blackjack type of brush.

2/ Plots were each one-fourth acre in size.

The results of the low-volatile esters are given in Table 2. The native oak brush on this area was crushed and broken down with a Marden brush cutter May, 1947. The regrowth, when sprayed in May, 1951 with selective herbicides in low-volatile esters, was quite dense and ranged in height up to 10 feet. In this particular study, very effective controls were obtained from only one application.

Most of the airplane spraying on the post oak-blackjack types of brush has been studied. Generally the powerful, slow-flying airplanes delivering a coarse spray have produced the best coverage. The quantity of acid to produce satisfactory control of the dense stands of the taller trees has not been definitely determined.

Some promising results on oak were obtained by using 4 pounds per acre of low-volatile esters containing equal parts of 2,4-D and 2,4,5-T, in diesel oil. Best results were obtained where 2 pounds of this material were applied the first year and additional annual treatments of 1 pound per acre the second and third years after the first treatment.

In earlier tests, diesel oil was most commonly used for airplane spraying. Some of the tests made in June, 1952, however, with water-oil emulsions at a rate of 4 parts of water to one of oil, appear to be about as effective as the oil treatments.

Airplane spraying during the winter months was not effective on hardwood species. Several tests were made during the winter of 1949 and 1950. The rate of application of 2,4-D and 2,4,5-T ranged from 1½ to 3 pounds per acre in diesel oil in quantities of 5 to 15 gallons.

Large-scale field trial studies with airplane applications on oak brush were started in June, 1952 at four locations in Oklahoma. These investigations were made cooperatively by Production Marketing Administration, Soil Conservation Service and Bureau of Plant Industry, Soils and Agricultural Engineering of the United States Department of Agriculture, Aerial Applicator's Association, Oklahoma A. & M. College and ranchers. Two of these tests were located in Osage County, one in Greek County and the other in Grady County. Evaluations of these studies will be made at a later date.

Table 2. EFFECT OF LOW VOLATILE ESTER HERBICIDES IN FOLIAGE SPRAYS ON OAK BRUSH

Guthrie, Oklahoma 1/

Kind of Chemical Applied 2/	Pounds of Acid in 100 gallon of water	Percent of Brush Remaining October 1952
Untreated(Check)	--	100.0
2,4-D	2	14.6
2,4-D	3	12.1
2,4-D	4	12.7
2,4-D - 2,4,5-T	2	13.5
2,4-D - 2,4,5-T	3	7.6
2,4-D - 2,4,5-T	4	9.8
2,4,5-T	2	10.5
2,4,5-T	3	6.7
2,4,5-T	4	9.2

1/ There was originally an average of 17,274 trees and shrubs per acre of the post-oak-blackjack type of brush.

2/ May 1951 on four-year old oak sprouts.

Non-Selective Herbicides. The non-selective herbicide "Ammate" (ammonium sulfamate) has also been effective on hardwood species (Table3). The rate of application used was 3/4 to 1 pound per gallon of water. This material was safer to use along roadsides, fence rows, orchards, etc., adjacent to crops sensitive to the selective herbicides. It was also effective during a longer period of the growing a season.

Other materials tried included three types of borax, a preparation of silicofluoride containing a trace of 2,4-D, and TCA sodium salt (trichloracetic acid). The borax compounds were not effective in foliage sprays but did kill oak brush when the powder was applied near the roots of each plant. TCA and silicofluoride, applied at the rate of three-fourth pounds per gallon of water, defoliated the oak. There was considerable recovery of plants sprayed with TCA, but silicofluoride killed a high percentage of both the oak and grass.

Discussion. The low-volatile esters were not as hazardous to sensitive crops as other esters. Best results have been obtained with selective herbicides when the soil moisture was adequate for ideal growing conditions, humidity fairly high, and there was a uniform air temperature of 60 to 80 degrees Fahrenheit with little or no wind. Under humid conditions, spray solutions of water have been satisfactory for selective herbicides and "Ammate". But when dry or more arid conditons were encountered, the addition of 10 gallons of diesel oil to each 100 gallons of spray solution of selective herbicides has increased the kill. The effectiveness of water solutions of "Ammate" was also improved by the addition of a spreader-sticker material recommended by the manufacturer.

TABLE 3. EFFECT OF AMMATE (AMMONIUM SULFAMATE) IN FOLIAGE SPRAYS ON OAK BRUSH

Guthrie, Oklahoma 1/

Date of Treatment 2/ Sprayed	Retreated	Percent of Brush Remaining October 1952
Untreated		100.0
May 1945	Sept. 1945	3.0
Sept. 1945	May 1946	6.0
May 1946	July 1946	5.8
July 1946	May 1947	5.6
May 1947	May 1948	3.7

1/ There was originally an average of 10,396 trees and shrubs per acre of the post-oak-blackjack type of brush.

2/ This chemical was applied on plots one-fourth acre in size at the rate of one pound per gallon of water.

When mixed species of hardwoods were sprayed, some plants were resistant to the herbicides. Retreatments were, therefore, necessary. Better results were sometimes obtained when the follow-up treatments were made with a different chemical from the one originally used.

Sprouts from stumps were difficult to kill with 2,4-D or 2,4,5-T foliage sprays. This was particularly true for sprouts that were not well established on the old roots of the original plants. Ammate foliage sprays were usually more effective in treating young sprouts. However, it was generally advisable to let the sprouts grow for more than two years before attempting to treat them.

Basal-Bark-Treatment

Basal-bark-treatments consist of completely wetting the bark around the lower part of each tree to the point of runoff. The spray materials were applied in bands 20 to 30 inches wide around the lower part of saplings and smaller trees and in axe incisions on trees larger than five inches in diameter. Applications were made during various seasons of the year.

Knapsack sprayers and fire fighters were handy and efficient for basal-bark-treatments of trees or small thickets of brush. For this use, they were fitted with oil resistant gaskets. They were also improved by attaching an extra length of pipe to permit the operator to stand upright while directing the solution to the base of plants. A pistol-type gun dispensing a solid stream of solution has also performed satisfactorily on air pressure units. This arrangement permits the operator to spray several trees from one position.

Powered orchard-type sprayers were also equipped with small jets for making basal-bark-treatments. Other powered equipment for this purpose now being investigated includes an experimental unit made by a private company at Oklahoma City. It consists of a framework mounted around the front and sides of a small farm tractor. Nozzles mounted in the frame direct a stream of solution at the base of the plants.

Selective Herbicides. Various selective herbicides were tested in basal-bark-treatment studies since 1949 on approximately 400 plots. The formulations included amines and esters. The esters were of isopropyl and butyl and the low-volatile type, butoxy ethanol and propylene glycol butyl ether. Another formulation tried was 2-methyl-4 chlorophenoxyacetic acid. Although much detailed data were accumulated from these studies, this report gives only summary statements of the most outstanding results.

The low-volatile esters have been the most effective for the basal-bark treatments. High percentage of both the tops and roots of the oak brush were killed with these esters in oil. In some places, however, more than one treatment was required to eliminate the brush. Summer applications were not as effective as winter treatments made from December 15 to March 15.

The low-volatile ester of 2,4,5-T applied in concentrations of 8 pounds of acid in 100 gallons of diesel oil, was the most satisfactory and produced a high degree of kill. Quite similar results were also obtained with 2,4-D of these esters applied in concentrations of 16 pounds of acid in 100 gallons of diesel oil. Mixtures of equal parts of 2,4-D and 2,4,5-T in concentrations of 12 pounds of acid in 100 gallons of diesel oil were not as effective as either herbicides alone applied in the concentrations given. The similar 2-methyl-4 chlorophenoxyacetic acid did not produce as satisfactory results as the other ester formulations.

Amines were not as effective as ester formulations for basal-bark-treatments of oak. However, quite similar results were obtained when either 2,4-D or 2,4,5-T was applied in concentrations as high as 48 pounds of acid per 100 gallons of water.

Where emulsions of oil and water of either formulations were applied, very poor results were obtained. The effectiveness of these selective herbicides was not improved by the addition of TCA or pentachlorophenyl.

Spraying the entire tree and brush during the dormant season with these various herbicides was not effective.

Non-Selective Herbicides. Two non-selective herbicides, Ammate (ammonium sulfamate) and CMU (3-P-Chlorophenyl 1,1-dimethylurea) were tried. Where Ammate was applied in axe incisions around small oak trees of 10 inches or less in diameter during late summer, good results were obtained. Crystals, as well as a solution of 5 pounds of this material per gallon of water, were effective.

CMU was applied on oak brush during the spring and summer, 1951 and April and June, 1952. The basal-bark-treatment, as well as applications of this material to the soil around the base of each shrub, was very effective. The rate of application was 15 pounds of CMU in 60 gallons of water per acre. It was also equally as effective in oil.

The brush and most of the native grasses were dead where CMU was applied directly around or on them. However, in September, 1952, following the April treatments in the area treated as close as one foot from the point of application, native grasses were growing normally and producing seed.

Stump Treatment

This method consists of spraying both the cambium layer of wood exposed on the stumps and the bark of the stumps to the soil line. The treatments were made immediately after the top of the plant was removed. The stumps and adjacent soil areas were thoroughly wet with the spray solution or completely covered with the powdered materials. More than 500 individual stumps were treated with different chemicals. Under most conditions, it was found desirable to cut only the larger trees, and to spray the small plants with either a foliage or basal-bark-treatments.

The ester formulation of 2,4,5-T was the best selective herbicide for spraying stumps. The concentration was 16 pounds of acid in 100 gallons of diesel oil. Ammate applied in the dry form or in solution of 5 pounds per gallon of water has given fair results. Other materials used were the chlorates and borax compounds. They were effective when applied in dry form or in solutions of 5 pounds per gallon of water. These latter compounds, however, sterilize the soil for indefinite periods.

GRASS PRODUCTION AND PASTURE DEVELOPMENT.

After the brush was killed, surprisingly large yields of grass and pasture were realized. Where selective herbicides were properly used, the leaves, twigs and stems of sprayed brush accumulated in a mulch on the soil. There was an average of 7593 pounds per acre of this litter two years after treatment. It conserves water and makes conditions favorable for the immediate growth of native grass intermingled in the brush. Measurements made during an eight-year period on the Red Plains Station show that 45% less water ran off annually from good grass on treated land than from an adjacent area of brush land.

This method of brush control continually protects the soil with adequate cover, providing fires were prevented. It has also been the safest way of changing worthless brush land into valuable grass land. In the Red Plains area, native grasses were in the undisturbed brush. The predominating species on the better sites were big bluestem (Andropogon furcatus), little bluestem (Andropogon scoparius), Indian grass (Sorghastrum nutrans), switchgrass (Panicum virgatum), purple top (Triodia flava) and sand lovegrass (Eragrostis trichodes). But, due to the competition of the brush, these grasses were small, spindling, and greatly depressed in growth. The original grass cover was more dense on areas having only light or medium brush cover. When clearing was limited to such sites, a complete land cover and full grass production was obtained more rapidly after brush was removed. Where this procedure was followed, good stands of native grass developed by the third years. The yield was five to eight times more than that produced on adjacent untreated brush land.

These native grasses were highly nutritious and have made valuable pasture. Grazing studies have been made during the growing seasons of the last nine years under controlled conditions on the Red Plains Station (Table 4). Cattle were in the experimental pastures from about May 1 to the latter part of August each year. These investigations were conducted on both eroded and formerly brush land. The highest cattle gains were obtained in 1952 from the cleared brush land pastures.

During recent years, fertilization was made a part of this experiment. Fertilizer greatly increased beef and grass production. The results were more outstanding on the eroded land. The pastures on virgin land, formerly in brush, produced approximately 1.7 times as much beef as those on eroded land. The one that was treated with chemicals produced slightly more beef than that cleared mechanically.

TABLE 4. BEEF PRODUCTION FROM ERODED AND BRUSH LAND ON THE RED PLAINS CONSERVATION EXPERIMENT STATION

Guthrie, Oklahoma

Kind of Pasturage and Land	Kind of Fertilizer Pound Per Acre Each Year	Pounds Animal Gain or Beef per acre 1952	Average
Native grass on eroded land	None	57	41 *
Native grass on eroded land	Equivalent of 100 lbs. superphosphate 100 lbs. ammonium nitrate	85	-- **
KR Bluestem mixed with Weeping lovegrass on eroded land	250 lbs. of 16-20-0	155	113 ***
Native grass virgin land cleared mechanically 1935-1943	None	96	69 *
Native grass virgin land treated with chemicals 1946-1947	None	104	72 ***
Native grass virgin land cleared mechanically 1935-1943	Equivalent of 100 lbs. superphosphate 100 lbs. ammonium nitrate	134	---

* Nine Year Average.

** Same Amount of fertilizer on a similar pasture on the Station produced an average of 79 pounds of beef per acre during a 5 year period.

*** Three Year Average.

BRUSH CONTROL IN THE FUTURE

R.H. Beatty, Ambler, Pennsylvania.

Chemical brush control has moved rapidly since the introduction of 2,4-D and 2,4,5-T in 1944 because the phenoxy acids offer selectivity, killing woody plant but not grasses. Their effectivenss at low concentrations opened the door to airplane spraying. Their formulation possibilities have given us several methods from which to choose. These, together with their low cost to the ultimate consumer, have been responsible for their wide acceptance to date.

Unfortunately, there have been claims of killing woody plants without a discussion of the economics involved, misunderstanding between volatility and spray drift, insufficient research data on the many factors responsible for success with our various methods and not enough data to cope with all toxicity problems related to poisonous plants, and so we have met with some disappointments. Because of these temporary setbacks, some folks have been disheartened and feel future answers lie in more basic work or in the introduction of new chemicals.

I hasten to agree that increasing the amount of basic research or imparting that information to workers in the field so that they can better determine the factors responsible for mode and method of action, increasing root suppression in crown area and in lateral rhizomes, the unexplained selectivity between species of a family or the introduction of new compounds to overcome some of the failings with our present chemicals would be most welcome. But we must realize that these goals will come step by step and that our success in the future will depend on all of us obtaining a more thorough knowledge of our woody plant problems, reaching agreement regarding the weaknesses of our present chemical methods, and working to make our present compounds more effective and less costly, gradually applying the results from basic research and continued field work.

To keep the viewpoint of this discussion as wide and unbiased as possible, I questioned many of the men active in the chemical brush control field regarding its future. The thoughts I offer today are based on information from their replies and on my own observations in the brush control field. I would like to express my great appreciation to these men for their whole-hearted support in replying to my questionnaire.

Our problem today in chemical brush control is not necessarily killing or controlling any given woody plant, but accomplishing it economically. The relation between the cost of our present methods and the revenue derived from using these methods is most important in any discussion which looks into the future. Whether our problem be that of increasing grass on rangeland, eradicating barberry or ribes to break disease cycles, or controlling mixed species of brush on utility right-of-ways, chemical treatment must be a sound financial investment. This point alone will determine future acceptance and point out future problems.

For example, with present methods we can kill almost any species of problem oak on right-of-ways where the economics involved allow us to use foliage sprays of Ammate or basal sprays of the phenoxy compounds. When the same oaks must be eliminated from Southwestern rangeland, the rancher does not feel that chemical treatment will give him sufficient return on the money he must invest, and controlling oaks on rangeland remains a sizeable problem for the future.

In some rangeland, we are fortunate that problem plants like mesquite and sand sage are susceptible to low-cost applications of 2,4,5-T and 2,4-D, and can be controlled by a program which fits into the economics of the land. Here our problems in the future involve finding materials or application techniques less hazardous to sensitive crops, and looking for more effective compound or formulations to eliminate the erratic results often encountered. Because of the return on chemical brush control investment the ranchers have accepted the present program on mesquite and sand sage, but they hope future research will reduce costs and offer chemicals and methods that are more consistently effective.

The question of whether we should try to kill all unwanted woody plants or just control them is an important part of the whole picture from both an economic and an ecological standpoint, and will play an important part in the future development and evaluation of new chemicals. In discussing this, let us interpret "kill" as meaning the death of the entire plant including roots and lateral rhizomes, and "control" as meaning a sufficient percentage of kill or inhibition to meet the demands of a given problem.

At Spur, Texas, those most familiar with the mesquite work would rather have a 50% root kill at $3.50 an acre than a 90% root kill at $10.00 an acre because of the new seedlings that appear. They grow slowly, so that inexpensive control fits into the economic pattern.

The men working in Oklahoma on sand sage feel strongly that this plant should not be completely killed, but that 50% to 75% control is more desirable for several reasons pertaining to sound range management. In the same area they would like to eradicate shinnery oak as completely as possible.

In breaking the wheat rust cycle, initial eradication of barberry is more economical than cheaper control measures that become expensive with repetition. On the other hand, ribes is intolerant of shade and combined with other procedures to encourage a desirable course of plant succession, control is sufficient in pine blister rust work.

The desirability of changing the vegetation on right-of-ways from woody to a low herbaceous cover means that the first sprays should kill as much of the undesirable brush as possible. Basal spot sprays can then be used to kill the remaining resistant species, leaving desirable low-growing plants as an effective biological control.

In the future we will hear a great deal of discussion comparing overall blanket sprays with selective spraying. Some ecologists in the Eastern part of the country are interested in developing a cover to inhibit reinvasion of unwanted trees and brush. This is now being accomplished by applying basal sprays to specific unwanted plants to eliminate competition and encourage heavier growth of desirable native covers.

Airplane and more recently helicopter sprays are being tried in an effort to reduce costs on inaccessible right-of-ways, trying to kill the mass of sensitive brush first and make it easier to get in and apply spot treatments to the remaining undesirable species. Providing we can overcome the drift problem with airplane application, acceptance of these methods in the future will be based entirely on whether or not they will reduce maintenance costs for the utility companies.

This brief discussion of kill and control is intended to point out that future chemicals or methods which offer a degree of control should not be interpreted as being less effective than those

which offer complete kill, but that each project must be appraised and will vary with plant species, ecological factors, and economic limitations.

Keeping these points of economics and control versus kill in mind, it seems evident that in future research we must improve the performance of present chemicals or find new ones if chemical brush control is to be used on projects where present results are unsatisfactory.

With few exceptions foliage application, whether by airplane or ground equipment, offers the most economical method of application approaching many of our present problems. Its weaknesses with regard to drift damage and with regard to insufficient top kill on some species and root suppression on others is a challenge which must be met.

In approaching the problems associated with increasing effectiveness we may endeavor to improve our present formulations, screen other known growth regulators for specificity to certain problem plants or develop new compounds.

Our present thinking on the subject of improved foliage spray is to develop a formulation or modify present compounds so they will be released into the leaves of woody plants at sub-toxic rates over a long period of time. We are of the opinion that a weakness with our present formulations is that they are too toxic to the foliage of certain plants and that in certain areas timing sprays in relation to downward movement of food is too critical. If a material can be developed which will enter at subtoxic amounts over a long period we may be able to overcome leaf toxicity, have the material available when translocation takes place, and build up a concentration of the growth regulator in the crown area as we do now with basal sprays.

That is our problem -- getting enough of the growth regulator or its breakdown products into the root-stem transition zone, or better yet into lateral rhizomes so it can inhibit latent buds in that area. There are many references in the literature indicating the very small amount of material which actually moves downward in relation to the amount applied to the foliage.

For the last few years we have tried to increase root suppression by adding extra oil to the water for foliage sprays. We are encouraged by the results under Eastern field conditions and offer the explanation that since our present esters are oil soluble, by extending the oil phase of the formulation we not only increase the volume of active material in the spray solution but, more important, we actually decrease the concentration of esters in this oil phase, thus reducing leaf toxicity with many plants. The amount of oil added will vary with plant species and stage of growth.

As basic work continues we will increase our knowledge regarding the use of adjuvants with phenoxy acids. It has recently been pointed out that indoleacetic acid inhibits activity when added to phenoxy acids while trichloroacetic acid may increase activity. The proportion of adjuvant used seems to be important in determining whether inhibition or activation results. This work with indoleacetic opens a discussion as to whether or not the phenoxy acid may be acting in the role of an antagonist to naturally-occurring hormones. Since most men working with growth regulators think there are numerous other natural hormones beside indoleacetic, we must look for other antagonists which may be specific in certain woody plants.

Our other approach to increasing the effectiveness of foliage sprays is through screening present growth regulators or new compounds for those which may be more specific in their mode of action in plants which do not show enough susceptibility to 2,4-D and 2,4,5-T. Perhaps a review of present phenoxy acids such as 3,4-dichlorophenoxy acetic and others is in order. The compounds may not show increased activity over 2,4-D or 2,4,5-T when applied to tomato or bean plants in our regular screening method but they may show selectivity toward certain woody plants. The recent field trials with 4-chlorophenoxy acetic and 2-methyl 4-chlorophenoxy acetic acid have brought out the differences in their selectivity toward various species.

A drawback at present in looking for selectivity toward many plants lies in the fact that several growth regulators are very expensive to synthesize and thus we may have only several grams available which is not enough to test all the necessary possibilities in looking for selectivity. We have recently planted ash, persimmon, basswood, oak and locust liners on our research farm and plan to screen known growth regulators for the reactions they produce in specific woody plants.

Another foliage spray problem which has caused poor public relations in several cases and may cause unnecessary legislation is that of volatility and spray drift. The introduction of the low volatile esters has minimized damage from phytotoxic vapors and it is reliably reported that atmospheric dilutions of ammonium sulphamate drifting across a field are normally below the amount necessary to injure crops. With the phenoxy acids the drift problem warrants future research. The recent introduction of airplane and helicopter spraying on right-of-ways increases the magnitude of this problem. I feel certain that the chemical formulator can offer formulations of present phenoxy acids which will minimize drift, but the practical application of such materials will be developed only by close cooperation between the agricultural engineer, the chemical formulator and the spray equipment manufacturer.

Our future approach to basal spray and stump treatment will center upon finding chemicals or formulations which will increase their effectiveness on plants which have the ability to resprout from underground rhizomes and upon reducing the cost of application.

The fact that the growth regulators must be directed to the base of the plant in sufficient volume that the material collects at ground line leads some of us to question to what degree the chemical or its breakdown products are moved in the root system and actually cause death of the root. We know that these chemicals do not move very far in most plants with lateral rhizomes and I am of the opinion that our greatest effect from basal sprays is in plants which can resprout only from the root-stem transition zone. In such plants the chemical apparently inhibits the adventitious buds present in that area.

In the future we should point out and acknowledge these different responses to basal sprays in terms of plant structure and not blame resprouting of plants with lateral rhizomes on faulty application, time of year or other factors which may not be the cause.

In order to reduce the cost of dormant sprays our research is pointed toward using oil-water combination in place of oil and the blanket spray in place of spot treatment. We have not been successful with the blanket spray but the oil-water mixtures are showing promise and we will expand our activities in this direction.

Stump sprays raise the same problem discussed for basal sprays and we need a great deal more research in this more promising and useful method. Perhaps CMU or a related compound may find a place in stump, basal or frill treatments. Preliminary results with this compound show definite toxicity to many woody plants but we must find methods to limit its effect to woody plants and reduce its residual and toxic effect on grasses and other wanted vegetation.

The future of brush control will also depend on how we handle other matters beside the control of woody plants. We must continue and increase our educationald programs as related to possible toxic effects on wild and domestic animals, fostering close cooperation with the Outdoor Writers of America so they are thoroughly familiar with the toxicity data and tests we must have before a chemical is released for general use.

We must always be conscious of the problem of poisonous weeds and brush in some fence rows, pastures and right-of-ways. There are indications that some of these plants are more palatable to animals after they have been sprayed with the phenoxy acids. There is data on this subject and more work is now in progress. When this work is published we must see that it is called to the attention of proper authorities in state and local government before unnecessary and unfair legislation is passed.

In conclusion it is evident that we must consider economics, plant habits and other ecological factors in appraising present chemicals or new compounds for killing or controlling wood plants.

We must increase root suppression in woody plants sprouting from the crown or lateral rhizomes and find new growth regulators or other chemicals more effective as foliage sprays for several of our problem plants.

The spray drift problem must be corrected or we must find less expensive methods to control plants during dormancy.

We must always keep in mind the viewpoints of others regarding poisonous plants and possible toxicity to animals, and foster close educational cooperation with all concerned.

The future of chemical brush control will depend on the initiative and cooperation of research men in our spray manufacturing and chemical companies, colleges, U.S.D.A., the extension weed specialists, the applicators, and the interest and encouragement they receive from the ultimate consumer. Judging from the success of the past years, our future looks most promising.

RECENT RESEARCH IN CHEMICAL BRUSH CONTROL

J.W. Suggitt, Toronto, Ont.

The Hydro Electric Power Commission of Ontario, along with many other utilities, was quick to recognize the economy and many advantages of right-of-way chemical growth control. Early work indicated that herbicidal chemicals could be applied to woody plants during the foliage season with excellent results. Later trials have shown that herbicides applied during the dormant growth season give even better response in the number of plants killed. Some of the results obtained and data relating to the conclusions drawn are presented in the following two subsections of this paper.

Part 1: THE FOLIAGE SPRAYING OF RESISTANT WOODY PLANTS GROWTH THE EFFECT OF TIMING, CHEMICAL CONCENTRATION, AND INCREASING CONTENT OF 2,4,5-T IN SPRAY FORMULATIONS.

Preliminary experimental work was carried out in 1948 and 1949 on the use of foliage sprays for right-of-way brush control. The results of this work were reviewed and published, (Chemistry in Canada, December, 1950), and gave data on the efficiency of eight commercial herbicide treatments in three growth zones of Ontario, and a table of species susceptibilities. Although about 70 different woody species were encountered only some 36 were present in sufficient abundance to give reliable statistical data for different treatments. It was found in the analysis of the 1949 data that certain species had relatively high resistance to treatment. These were selected for further study in 1950 and 1951 with the aim of determining the most effective combination of chemical, concentration, and time of treatment.

MATERIALS AND METHODS

The experimental work was carried out near Toronto (a cold temperate deciduous region) during the summer of 1950. Recounts were made 12 to 13 months' time after foliage treatment. Nine species, seven treatments, and four groups at different dates of application were included in the experiment. These are detailed as follows:

Resistant Species Studied:

Ash	Hickory	Maple(soft)
Basswood	Hornbeam	Oak (black)
Hawthorn	Maple (hard)	Oak (white)

Foliage Treatments Applied:

A- Ammate at 0.75 pounds per gallon.
B- Ammate at 0.50 pounds per gallon.
C- 2,4-D at 1500 ppm plus 2,4,5-T at 1500 ppm.
D- 2,4-D at 2000 ppm plus 2,4,5-T at 1000 ppm.
E- 2,4-D at 2400 ppm plus 2,4,5-T at 600 ppm.
F- 2,4-D at 1000 ppm plus 2,4,5-T at 2000 ppm.
G- 2,4-D at 1000 ppm plus 2,4,5-T at 1000 ppm.

Time of Application:

Group	Date of Treatment(1950)	Date of Recount(1951)
1	June 1 - 7	July 23 - 24
2	July 6 - 14	July 26 - 27
3	July 25- August 3	July 30 - 31
4	August 14 - 23	August 2 - 3

For each group, and for each chemical, fifty stems of each species were tagged with a numbered card before treatment. The total number of stems tagged was 12,600. The tags were attached to the main stems with a loop of coloured plastic wire, and different colours were used for each treatment to permit some identification if the tags deteriorated with weathering. For each stem a record was kept of species, height at time of treatment, location, and degree of stem kill and resprouting. Not all stems were seedling growth; many were regrowth from old root systems and had sprouted since the area was last cut over.

At the time of recount, the condition of each stem was determined by examination of the cambium layer. With a sharp knife, each stem was scratched, and classified as unharmed (no stem kill), 25 per cent, 50 per cent, or 100 per cent killed, according to the proportion of stem showing a green cambium layer. This was found to be more tedious but more reliable than an estimate based on foliage conditions. With the method of classification used for these experiments it is

clear that no recovery is possible for that part of a stem which is already dead.

OBSERVATIONS AND DISCUSSION

The results of the tagged-stem experimental spray applications carried out during June - August, 1950 were observed and recounts made during July - August, 1951, or about 12 to 13 months' time after treatment. This was felt to be a sufficiently long interval, (and after the second season of active growth for these stems), that observed results on the degree of stem kill and the amount of basal re-sprouting would be valid.

A great variation was observed in the reaction of similarly classified individual stems. The variation is undoubtedly due to the combination of many factors which are not easily defined or controlled. One factor is technique of applying the material. This was controlled as far as practical within the series of experiments, but in general may differ a great deal from the technique used on a large scale with power equipment. Another factor, which which was not controlled, is the size of root system upon which the stem depends. The effect of this factor was noticed during recounting. Two adjacent clumps of white oak, treated in Group 3 with Ammate 0.50 pounds per gallon, reacted so differently that some explanation was sought. Of the fifty stems, thirty-seven were suckers from small stumps and were severely affected, while twelve stems which were suckers from a large stump were totally unaffected.

With the herbicide solutions used, a considerable difference was observed in the results obtained with ammonium sulfamate and with phenoxy-acetic-type materials. The ammate solutions are less selective and give high degrees of stem and root kill on all susceptible and most resistant types of growth. In this work the concentration of the ammonium sulfamate used was lower than that recommended by the manufacturers and by other workers. The recommended concentration is usually 1.0 pound per U.S. gallon. The results indicate that a concentration of 0.75 pound per U.S. gallon gives excellent results at a lower cost per gallon. The use of 0.50 pound per gallon ammate soluation as a foliage spray gives good results during most of the season, but is less successful in controlling resistant species. It would seem that the lowest rate of application (0.50 pound per gallon) is on the borderline in giving consistently dependable results. The use of 0.75 pound of ammonium sulfamate per U.S. gallon is recommended where this type of spray is required.

Ammate has definite advantages in use, e.g. its non-volatility and the excellent over-all kill obtained with one thorough spray application. However it has many disadvantages. The corrosiveness of the ammate salt solution and its deleterious effect on spray equipment and leather are well known. Even at the lowest application rates the bulk and weight of the dry ammate salt which must be transported to the spray site is considerable, and for the spraying of right-of-way in remote areas, the transportation of this chemical becomes a real problem. The high cost of the ammate makes extensive use of this material impractical for foliage spraying. Although ammonium sulfamate has advantages in the degree of kill obtained, it is a much less attractive spray material than 2,4-D and 2,4,5-T.

The phenoxyacetic type of herbicide is more selective, and certain species such as maple, basswood, oak, ash, and hickory are harder to kill. Susceptible species are killed with 0.15-0.25 per cent sprays of 2,4-D and 2,4,5-T (1:1), while the satisfactory control of resistant species requires a mixed acid concentration of 0.25 - 0.35 per cent. Application of a 2,4-D and 2,4-D and 2,4,5-T foliage spray at a concentration of 1.05 per cent did not increase the number of stems killed by more than four per cent (84 per cent), and it is now considered uneconomical to work with foliage spray concentrations of D and T at rates higher than 0.40 per cent. The data presented show the results found when the herbicide was applied during the period of maximum plant susceptibility. Application of herbicide at other periods would show poorer results with resistant species. The time during the foliage season at which the spray is applied has considerable influence on the percentage of stem kill obtained.

For susceptible species, a spray of 0.30 per cent D and T gives excellent results for about 100 days after bud-break. In southern Ontario, bud-break usually occurs about the middle of May. Hence satisfactory kills of susceptible species are encountered during all the growth season and until about the third week in August, after which less satisfactory results may be expected. Greater amounts of regrowth from susceptible stems occurs in the year following a late spraying. This and other generalizations made in this paper must be qualified with the observation that wet weather or moist soil conditions will tend to prolong the active growth season and lengthen the acceptable spray season.

Resistant species do not always respond readily to 0.30 per cent D and T foliage sprays. The resultant kill obtained depends on the time after bud-break that the spray application was made. Efficient kills are obtained in a period of 20 to 70 days after bud-break, or from the time of full leaf spread to the end of the time of most rapid growth. In southern Ontario this period would be from the first week in June until the third week in July. Differences in latitude may extend or decrease this period of most efficient application of herbicide for resistant species. After August 1st, there is a considerable diminishing of 2,4-D and 2,4,5-T herbicidal efficiency, and regrowth is more severe the following year from resistant stems sprayed late in the season.

The resistant species treated with ammate, show a similar decrease of herbicide efficiency when ammate foliage spray applications are made late in the growth season. The same general period of most efficient kill is observed, but with ammate the period of effective stem kill is prolonged and excellent results can be obtained with foliage sprays made in late August.

The effect of increasing the 2,4,5-T content as a percentage of the total acids in 0.30 per cent foliage sprays was studied. Four different spray formulations of 2,4-D and 2,4,5-T isopropyl esters with a mixed total acids content of 0.30 per cent were prepared and applied at four stages during the growth season.

Spray applications made during mid-June on actively growing plants show that the effect of the 2,4,5-T content of the foliage spray is then most pronounced. Increasing the 2,4,5-T content from 20 to 50 per cent in the formulation gives a 15 per cent increase in stem kill on all resistant species. The effect of increasing the 2,4,5-T content from 33 per cent to 50 per cent is relatively smaller (6 per cent) than would be expected.

Late-season spraying (during August) gives poor results on resistant species no matter how little or how much 2,4,5-T is present. The data gave practically a straight line at 34 per cent stem kill. A slight but definite trend to less control with high concentrations of 2,4,5-T may be noted.

The average stem mortality for different D and T formulations, based on 4800 tagged stems,

show that the over-all increase in stems killed for the increasing proportion of 2,4,5-T is not as great as might be expected. An increase in 2,4,5-T content from 33 per cent to 50 per cent in the spray formulations results in only an over-all 3 per cent greater kill of resistant stems. It would appear that the use of equal portions of 2,4-D and 2,4,5-T gives only slightly better results than a combination of 2 parts 2,4-D to one part 2,4,5-T. The use of a 2T:1D combination must be dismissed on the basis of a considerably increased cost and only slightly improved stem kills over the 1D:1T combination. The application of a 4D:1T combination (20 per cent 2,4,5-T) might be considered in areas where only semi-resistant species or bramble are found. For application to woody-growth stands where resistant species are abundant, the results are too variable to give a reliable stem kill, and results generally are not as good as is indicated by the numerical data.

About the best stem mortality in resistant species is obtained with the 1D:1T combination (equal weights of 2,4-D and 2,4,5-T acids in the isopropyl ester form). Increasing the 2,4,5-T content of the spray does not ensure a greater percentage stem kill. The use of a 2D:1T combination gives almost as good results as an equal-parts mixture of 2,4-D and 2,4,5-T and might be considered because of the greater economy of this formulation.

CONCLUSION

A Materials

Ammate

(1) The use of ammonium sulfamate as a foliage spray is less selective with resistant species than are combinations of 2,4-D and 2,4,5-T.

(2) Ammonium sulfamate at a concentration of 0.75 lbs. per U.S. gallon appears to be the economical and efficient non-selective spray to use. At a concentration of 0.50 lbs per U.S. gallon, the percentage of stems killed is still very high but results are more variable.

(3) Although ammonium sulfamate is more effective and less selective than phenoxyacetic-type herbicides, other inherent properties such as the bulking factor, corrosiveness to equipment, high cost, and difficulty in handling, make amate a less attractive spray material than mixtures of 2,4-D and 2,4,5-T.

2,4-D and 2,4,5-T

(4) Foliage sprays incorporating combinations of 2,4-D and 2,4,5-T are selective and certain deciduous woody plant species are "resistant" to control.

(5) A 2,4-D and 2,4,5-T (1:1) mixed acids concentration of 0.25 - 0.35 per cent in the ester form appears to be the most efficient and economical foliage spray to use on mixed susceptible and resistant species.

(6) Susceptible species are controlled with 0.15 - 0.25 per cent sprays of 2,4-D and 2,4,5-T(1:1).

(7) The effectiveness of 2,4-D and 2,4,5-T mixed ester (1:1) appears to increase only slightly with increasing concentration in the range from 0.35 to 1.05 per cent total acids.

B Application Time

(8) The most effective time for the application of foliage sprays is in a period from 20 to 70 days after bud-break, of from the time of full leaf spread to the end of the period of most rapid growth (i.e. June until the third week in July).

(9) After the first week in August, there is a considerable decrease in the efficiency of 2,4-D and 2,4,5-T herbicide sprays. In the year following treatment, regrowth is more severe from resistant stems sprayed late in the season.

(10) The period of effective stem kill is prolonged with ammonium sulfamate, and excellent results can be obtained with late-season foliage sprays of this material.

C Increase in Content of 2,4,5-T

(11) The effect of increased 2,4,5-T content in foliage sprays is most pronounced when applied during mid-June on actively growing plants.

(12) Late-season spraying (during August) gives poor results on resistant species no matter how little or how much 2,4,5-T is present.

(13) The best stem mortality in resistant species is obtained with a 0.30 per cent foliage spray of 1 part 2,4-D and 1 part 2,4,5-T. Increasing the 2,4,5-T content of the spray does not ensure that a higher percentage of stems will be killed. The use of a foliage spray of 2 parts 2,4-D and 1 part 2,4,5-T gives almost as good results as an equal-parts mixture of 2,4-D and 2,4,5-T, and might be considered because of the increased economy of this formulation.

Part 11: BASAL BARK DORMANT SEASON TREATMENTS ON RESISTANT WOODY PLANT SPECIES, THE EFFECT OF TIMING, CHEMICAL, CHEMICAL CONCENTRATION, AND THE AROMATIC CONTENT OF THE OIL CARRIER

Introduction

During the winter of 1949-1950, preliminary experiments were carried out on the use of herbicides as dormant-season basalbark sprays for the control of woody growth. This work, when reviewed during the summer of 1950, proved to be most encouraging in giving control over certain species which were resistant to summer foliage sprays. Other advantages were the ease of treatment and the excellent kill obtained on specimen woody plants, which ranged up to 12 to 15 feet in height. The good control obtained over maple, hawthorn, hickory and oak, in addition to all the more susceptible species, made this treatment particularly valuable. During 1950-1951, intensive experimental work of a more extensive character was planned and executed during the dormant growth season.

Materials and Methods

In the period October 1950 to May 1951, thirty-five experimental plots, each a staked area of one-twentieth acre, were treated with various herbicides and herbicide concentrations. The herbicide formulations in oil were prepared in the laboratory. Applications of the chemical solutions were made on the fifteenth day of every month between October and May, excluding December. A survey was made of the dominant and co-dominant species of each plot. Of the fifteen species common to most plots, eleven species would be classified as resistant if the herbicides were applied as foliage sprays.

For the dormant-season basal-bark spray treatment, the oil-herbicide solution was applied by knapsack sprayer to the bark at the base of the plant and to the trunk and lower branches to a height of 3 to 3½ feet. In this manner a relatively large volume of

spray solution was applied per acre of brush (of normal growth density), i.e. 60 to 75 gallons per acre. Earlier work had shown that low volume applications of concentrated herbicide did not give consistent results even with the same species, whereas higher-volume applications at nominal acid strengths had given superior kills of woody growth.

During February 1951, further tests were conducted to determine the effect of the aromatic content of the oil carrier used as a diluent for the concentrated herbicides. Through the courtesy of the Imperial Oil Company, a series of five different oils of widely varying aromatic content were used in the experimental application. By holding the herbicide strength constant of 16,000 ppm of 2,4,5-T, the effect of varying the aromatic content of the diluent oil on subsequent plant kill was studied.

Observations and Discussions.

The results of the spray applications made on test plots in the winter and early spring of 1950 to 1951 were observed during late August and September, 1951.

With the herbicidal solutions used, a considerable difference was observed between the results of applying the esters of the 2,4-D and 2,4,5-T combination, and 2,4,5-T ester alone. The application of 2,4,5-T ester in oil gives the best results.

The use of water as a diluent for herbicides used in dormant spraying in place of fuel oil would, of course, reduce the cost of the spray considerably However, the use of water as a carrier in dormant-season basal spraying gave much less satisfactory results than when oil was used as the carrier.

The use of high-volume oil sprays of 2,4,5-T gave consistently better control than low-volume applications. When 60 to 75 gallons of oil-herbicide were applied per acre, the resultant control obtained was 10 to 25 per cent greater than when the same amount of 2,4,5-T acid was applied in oil at rates of 10 to 20 gallons per acre. Thus high-volume sprays with thorough stem wetting give superior results.

The aromatic content of the oil carrier has some bearing on the resultant effective kill. Oils with a 0 to 30 per cent content of aromatic fractions are more effective than oils with higher aromatic oil contents. Used transformer oil (18 per cent aromatics): diesel oil, stove oil and No. 2 fuel oil are all satisfactory for use as diluent oils.

A concentration of between 1.2 per cent and 1.5 per cent of 2,4,5-T acid (12,000-15,000 ppm) in oil appears to be the most potent and economical spray solution to use in dormant basal-bark spray operations. The use of higher concentrations of 2,4,5-T will give better results, but the increase in cost of the herbicidal spray solution is out of line when compared with the slight increase in resultant effectiveness.

The relation between time of application during the dormant season on the resultant kill of woody growth is definite. Early dormant-season applications of 2,4,5-T oil as a basalbark spray, (from late fall until January) gives generally poor and unreliable kills with considerable basal resprouting. Applications of 2,4,5-T in oil on dormant growth from February until May gives an excellent kill of all species. The later the application of the herbicide is delayed (that is the nearer to bud-break the application is made) the better are the results. For best results the application of dormant sprays should be delayed until bud-swelling is noticed during early February.

Where snow lay on the ground at the time of spraying, burying smaller stems and roots, or where "misses" occurred, there was regrowth on all species of stems equivalent to that present on control plots. Sumac and poplar sprouted from lateral roots of the parent plant with no strong evidence of lateral translocation of herbicide, at least within the first growth season after treatment. Only upward translocation of the herbicide could be observed.

Dormant basal spray applications are most valuable on maple where growth is rendered weak and depressed. A few red maple stems (less than 25 per cent of all the maple stems on any one plot) had sent up a few feeble new shoots. Data from the 1949-1950 dormant spray work show that these may die during the following winter.

Root kill was observed or is probable for all species which show dead cambium on all stems to ground level, and which did not resprout during the active summer growth season. All susceptible brush species were easily controlled, and only basswood and maple of the nine resistant species normally encountered showed any regrowth from the main stem. Excellent top kill was obtained at 1.6 per cent of 2,4,5-T in oil with every species except basswood, but basal resprouting occurred with early winter spray applications on basswood, maple (hard), ash (white), and hickory. The only species offering strong resistance to dormant basal spraying is basswood, and this species is only controlled with liberal high-strength (2,4 per cent) applications of 2,4,5-T ester in oil.

The physical characteristics of the oil used as a diluent for the herbicide must be carefully evaluated. Certain specifications, aside from the aromatic oil content, must be imposed. The diluent oil must not be corrosive to spray equipment nor have an objectionable odour. The diluent oil must be compatible with the concentrated herbicide and mix in all proportions. Freezing temperatures must not cause coagulation or gelation of the oil, otherwise spraying in cold weather would be untenable. The viscosity of the oil at all temperatures must be such that an easy flow from standard nozzles is obtained, and finally, the flash point of the diluent oil must be sufficiently high that no flash-fire hazard will exist during spraying operations.

Conclusions

(1) The use of 2,4,5-T in oil as a dormant-season basal-bark spray is more effective than 2,4-D, or a mixture of 2,4-D and 2,4,5-T.

(2) The most effective time of treatment is during February, March, April and May, or after the time when bud swelling begins and before bud-break. Herbide applications made during the late fall and early winter (to January) are not as effective as later treatments.

(3) A herbicide concentration of between 1.2 per cent and 1.5 per cent of 2,4,5-T (acid basis) in an oil carrier appears to be the most potent and economical spray solution to use as a dormant basal bark spray.

(4) Diluent or carrier oils of an aromatic oil content between 0 and 30 per cent appear to give slightly better control of regrowth (in combination with 1.6 per cent 2,4,5-T) than do oils of higher aromatic content. Thus used transformer oil, diesel oil, stove oil and No. 2 fuel oil are all satisfactory for use as diluent oils.

(5) The use of water as a cheap diluent for 2,4,5-T in dormant spraying is much less satisfactory than when oil is used as the carrier.

(6) High-volume oil applications of 2,4,5-T at 60 gallons per acre give better control than low volume (20 gallons per acre) applications. High-volume sprays give better stem wetting and superior results.

(7) Dormant basal-bark sprays show advantages over foliage sprays in the control of many resistant species, such as maple, ash, hickory, and oak. Sumac and poplar tend to sprout from lateral roots. Basswood was the most difficult to control, and required very high concentrations of 2,4,5-T in oil to give good mortality.

(8) Resprouting from the root or at the ground line occurred with early dormant-season (October - January) basal-bark spray applications of 2,4, 5-T on such resistant species as hard maple, white ash, and hickory. Applications of 2,4,5-T made later in the dormant season (February -May) gave little or no resprouting on these species. Basswood showed basal resprouting despite treatment at all periods.

(9) The physical properties of the diluent oil, such as the freezing point compatability with herbicide concentrates, flash point, aromatic content, and viscosity, must be carefully evaluated before use in the dormant season.

DORMANT SPRAYING OF WOODY GROWTH

L. Playfair, Manitoba Power Commission.

Since 1948 the Manitoba Power Commission has been engaged in spraying with 2,4-D and allied chemicals as a means of controlling woody growth which infests approximately half of its 25,000 miles of transmission line. Following the success of basal dormant trials we thought that it should be possible to obtain similar results by machine applied dormant over-all treatment. This would permit of more efficient use of trained personnel and reduce the number of units required to cope with the woody growth problem. Consequently it was decided to try this method of killing brush, using the turbine machine which had been doing foliage spraying.

In the late fall of 1950 we carried out extensive experimental dormant spraying using a Buffalo Turbine and substituting diesel oil for water as the carrier. Part of spraying was with 2,4-D alone and part with a mixture of 2,4-D and 2,4,5-T. Rate of application was about 2 pounds acid equivalent per acre in from 10 to 15 imperial gallons oil. When the mixture of D and T was used it was in the ratio of 1/3rd T to 2/3rds D. Further trials were conducted in the Spring of 1951. A careful check of the results of these tests indicated that we could control most, if not all, of the species native to the province.

In experimenting with the Turbine and oil treatment some plots were sprayed by aiming the solution at the bottom of the growth, others by trying to wet the whole tree or shrub. The latter method gave the better results. It was also found that a mixture of 2,4-D and 2,4,5-T was more effective than the 2,4-D alone.

In the late fall of 1951 we started on large-scale dormant spraying. Operations were carried out during the months of October, November, December and into January of 1952 when the snow put a stop to the project. We started again with dormant spraying in April of 1952, continuing until growth was in leaf in early June at which time we switched to normal foliage spray with water the carrier.

With the exception of changing from water to light or medium diesel fuel oil, we do dormant spraying in exactly the same manner as with foliage treatment. Results depend upon adequate coverage. It is interesting to note the manner in which the oil will creep around the trunk of a small tree which has been sprayed from one side only. Immediately after the machine has passed, an examination of a tree of about 1½ to 2 inches in diameter will show that the oil has covered about 2/3rds of the surface. However, in about 15 to 20 minutes the oil will have crept around the trunk and will show almost complete wetting of the bark. This holds true of course for the smooth bark species, but is not the case with the rough barks such as Burr Oak so common in Manitoba. In our opinion it would be very difficult to obtain as satisfactory coverage with low volume spraying when using any other type of machine. We believe that in low volume application an air blast machine will give the best coverage.

With dormant application we ran into several problems that had not been encountered in foliage spraying. Cold weather was probably the worst, as at times the temperature was well below zero. Not only did this make working conditions rather difficult for the men, but during the most severe weather the chemical had a tendency to congeal before it was taken out of the containers. We installed a canvas shelter on three sides and over the top of the machine, leaving the back open to allow the Turbine to operate. The chemical was left in a warm place in the town where the crew secured oil and in this way kept in a fluid condition. Winters in Manitoba are usually fairly windy and this added to our trouble. The crew were supplied with a detailed map of the area in which they were working. This map showed on which side of the road allowance the power line was located. They would plan each day's route according to wind direction, as it is essential when using a Turbine to spray with the wind.

The disadvantages of working in the winter are offset to a considerable extent by the advantages. For instance, there are no crops at that time to damage by the spray solution. Better penetration is obtained when no leaves are present. Another advantage is that we can frequently spray from the field-side of the line which in some cases is much closer to the brush being treated, than the travelled portion of the road allowance.

Growth treated consisted of Poplar, both black and white, Saskatoon, Chokecherry, Willows, Burr Oak, Wild Rose and Hazel. In some locations the poplar had reached a height of 25 feet. White poplar is the most prevalent, followed by the willows. Of the several species, white poplar is the most troublesome as it grows into the wires more quickly than the others. All species except oak and hazel, appear to respond very well to dormant treatment. Oak and hazel were definitely set back, but the oak leafed out to some extent late in the summer and there was a little regrowth from the roots of the hazel. Poplar, regardless of size appeared to be killed.

During the dormant season of 1951-52 we treated 240 miles or 960 acres of brush on rights-of-way. This was accomplished in 50 working days. 420 gallons of an 82 oz. acid equivalent per imperial gallon mixture of D and T in 12,044 gallons of light diesel oil were used. The total cost of the operation was $8,370.00. On an acreage basis this works out to about 2½ lbs. of acid per acre in 12½ gallons of oil. The cost was $34.87 a mile or $8.72 per acre.

In looking at the over-all picture we are well pleased with the results of dormant treatments. Naturally we are a little concerned over the failure of this type of application to kill the burr oak, but fortunately it is not the dominant species and only causes trouble on a limited portion of the system. We are inclined to think that low volume dormant spray will not kill oak because of its rough bark, but we feel confident that by using a higher

volume, 25 to 30 gallons per acre, this species could be controlled.

Following the examination of the sprayed brush treated the winter 1951-1952 a custom spraying company purchased a turbine machine and embarked on fairly large scale dormant spraying early this winter. Our own machine has been working since the middle of October and by the end of November had treated approximately 120 miles of right-of-way. To assure ample coverage we increased the volume of oil slightly to 15 gallons per acre. Due partly to better weather and also to more experience on the part of the crew costs are running slightly below those of last year.

BRUSH CONTROL ON RIGHTS OF WAY BY BASAL, STEM, AND TRUNK TREATMENT

Glvin Durr, Clinton, Missouri

Telephone companies' and power companies' pole lines, with the exception of transmission and toll lines, must be located along the public roads and highways as it is along these public roads and highways the customers that they must serve are located. In some areas the value of the land is such that these pole lines can use a direct route with easements on private property, but in most instances in an average rural distribution, the land-owner does not welcome additional poles set in his fields that he must farm.

Since the beginning of the first telephone line, which was a long time before we had any highways, highway departments, or public planning, the old country road was used as a right of way for the distribution of service. In recent years public roads have been taken over by highway departments and roads in general have improved.

When these rights of way were taken over by public departments, restrictions were placed not only on the building of new pole lines along the highways, but sometimes permission for the clearing of the brush from these existing rights of way has been hard to obtain.

In many instances, highway beautification programs, garden clubs, and arbor clubs have carried out their projects without taking into consideration the utilities that were already using these rights of way. Working in harmony with the beautification programs could result in the desired beautification without interference to existing utilities.

It is not the intention of any public utility to try to obtain permission nor do they want to obtain permission to cut beautiful shade trees or any other trees along the rights-of-way that are of value to the property owner or the highway program in general.

Some conservationists object to the clearing of the brush from the fence rows as they claim that wild life cover has been destroyed, but on the other hand, wild life is not supposed to be pursued along the highway, and to create a habitat along the highway encourages hunters to disobey the law. We have no figures available, but from our own observation we believe that a large amount of wild life is killed each year by automobiles on the highway.

Many property owners have found that multiflora rose make a very good fence or wild life cover, and at the same time does not interfere with utility lines.

In many instances companies or individuals using chemical brush control have unnecessarily browned the roadside or have killed brush that they did not intend to kill, and it is this reckless application of chemical brush control, if continued, that will affect the extent of chemical brush control, in these immediate areas and their effects will also be felt in adjacent areas. Permission, caution, and just good horse sense should be used in the carrying out of your program in order to avoid adverse criticism that could easily affect the entire program.

After you have studied chemical brush control and conducted the experiments you think are necessary to convince yourself of the expected results, then go into the program whole-heartedly, keeping in mind at all times the public relations angle, and your program will be a success.

Foliage spraying, basal spraying, and stump treatment have their advantages and disadvantages. However, stump treatment is a must and does not conflict with either the foliage or basal treatment. Where very wide rights of way have to be covered, foliage application is still the most economical method to use and there are no arguments against the use of it in these instances. Foliage spraying leaves much to be desired, and while basal treatment does not have all the answers, it has the following advantages over foliage spraying.

It can be done many more months out of the year and it reduces the drift and the volatility hazard, thereby making it possible to control the brush in areas where there are susceptible crops and the use of foliage spray would not be advisable. The treatment can be made during the winter months when other vegetation does not hide the smaller sprouts from the operator. It is during these winter months (storm periods exempt) that we have more manpower available to clear our rights of way. We are convinced that we get a high per cent of kill and less resprout by using the basal treating method. Another great advantage in the basal treating done during the dormant period is that permission to clear rights of way can be secured more readily than when the trees are leafed out and in their full beauty.

In the spring of 1949 we did our first basal treating on an experimental basis and the results were good enough to prompt further experimenting with this type of application. We have tried various percentages of chemical, several methods of application and have covered different areas of the plant. We have also used this method every month in the year, noting the results the following year.

Our experiments justified this type of treatment as a standard practice. In the spring of 1951, we started our basal treating program continuing through the winter of 51 and 52 and the results are so good, that our program is being continued and expanded on this type of application.

We have found that by using one gallon of a 4-pound acid, 2-pounds of 2,4-D and 2 pounds of 2,4,5-T with forty gallons of No. 2 fuel oil and applying this to the lower 15 inches of the plant with enough volume, so that run-down will occur equal to the amount required to saturate the 15 inches, gives us best results. In other words, the amount applied to the plant in volume will be equal to what it would take to saturate 30 inches of the plant, but we feel that it is essential to have the run-down at the ground line rather than to wet the plant above the 15 inch height.We have experimented with much stronger concentrations and believe that we are getting the best results with a smaller concentration and more volume.

The method that you choose to apply the chemical will depend upon the area and the extent of your operation. It may vary from the knapsack sprayer to power equipment using low pressure for

application. If you use power equipment, your nozzles and pressure should be such that the waste of the chemical is at a minimum as the cost of wasted material is much higher than when using foliage application.

We have experienced resprouting on species such as elm, willow, and other normally thought easy-to-kill brush. This resprouting has also been noticed in our foliage application. Therefore, this past summer we have basal treated some elm and willow with 2,4-D in oil, using a 6 pound acid in the ratio of one gallon of acid to thirty gallons of oil. Our results looked promising, but we will not be able to determine the resprout problem until next year. This winter we are going to continue using some 2,4-D on these plants in an experimental way.

I will describe the results that we have found by using the basal method, starting in the spring when the foliage is full.

Plants basal treated during this foliage period are slower to show visible reactions than when using the foliage spraying method. Approximately one week to 10 days after the plant has been treated, you will note that the leaves will take on a different appearance and sometimes will even be distorted in their growth. Then, during the next week, the leaves located on the stems farthest from the trunk will start to discolor and die on the very tips,and this dying process will continue until the whole plant is brown. Sometimes it is a month before the chemical is translocated to the upper part of the plant. However, the time required for translocation to the root system is much longer. The leaves remain on the plant in a browned condition for a long time and I am happy to say that a large percent of plants treated during this period never come back to life again.

There is very little difference in the reaction in the plants treated during the foliage period up to and including a light frost. During the period from a killing frost, when the plants start to shed their foliage and assume their foliage and assume their dormant stage, from the middle part of November to the first part of December, depending upon the season, many plants treated with the basal method fail to leaf out in the spring. The percent of kill is high with very little resprout occurring.

The plants sprayed from early winter until early spring will leaf out in the spring and no visible of treating will be seen other than that some plants will leaf out a few days earlier than adjacent plants of the same species that were not treated. Soon after leafing out in the spring the treated plants began to die. The first signs of dying start in the top of the brush or tree. This process continues throughout the growing season, with some species the reaction is much faster than in others. Maple, elm and willow die more readily than do ash and oak. The percent of kill is high with very little resprout occurring.

We have found that when the treating is done in late spring when the plant is again becoming active, the plant not only leafs out normally, but in many instances keeps right on growing. Therefore, during this period our results have not been too good, and we are not applying it on a scale other than experimental during this period.

There are many recommendations as to the percent of acid in oil for best results as each manufacturer seems to have a different idea as to what is necessary to obtain to kill. Our experiments have shown that the best results were obtained by a larger volume of less concentrated chemical than by using a smaller amount of higher concentration. By concentration we mean the percentage of acid to oil.

Many recommend using a straight 2,4,5-T for basal treating while our results have shown that we get a higher percentage of kill with less resprout on all species when use both 2,4,5-T and 2,4-D.

As in foliage spraying 2,4,5-T will kill some plants better than 2,4-D while on other plants, 2,4-D will kill better than 2,4,5-T, but in practical application where varied species occur, we must be content to use a solution containing both of the chemicals and then follow up on the resprouting with the chemical that kills the plant best.

We believe it is essential to secure a kill as soon as possible as continued retouching jobs tend to build up a resistance to the plants against the chemicals used.

In order to mark the plants sprayed, we are using a dye (National Oil Red "O") in our material. This not only identifies our work from what the farmer or property owner does, but a smaller percent of plants are missed by the operator with the use of this marker. We have found no bad effects that this dye has on the action of the chemical.

We have noted, as some of you have, that for some reason or other two plants of the same species located near each other have different percentages of kill. One may resprout and the other may be so dead that a fungus growth has already started on the plant. Some think that this is due to some plants being more resistant to the chemical than others, but by noting our results through the use of this dye marker, we are of the opinion that the reason that the results were not the same on the two plants is that the operator did not adequately treat one of the plants.

For the last eighteen months, we have followed the practice of cutting all the large brush that interfered with our lines and treating the stumps on all the brush that we cut immediately after cutting it. The remaining brush and many large trees that did not actually interfere with the clearance necessary, were basal treated. We have cleared many miles of right of ways using the above method with no adverse criticism whatsoever that sometimes occurs and is the potential danger when using foliage spray.

We have observed the results of our basal treating for several years and the results that we have obtained justify our continued use of this practice.

SERVICE ORGANIZATIONS' PART IN A PLANNED BRUSH CONTROL PROGRAM

Charles O. Laverty, Indianola, Iowa.

A service organization's part in a planned brush control program can be summed up in one sentence, "Give the customer a high degree of kill at the lowest per unit cost and maintain good public relations". It is needless for me to elaborate on the technique of spraying since this conference is being devoted to this very topic and others on the program are much more qualified than I to make recommendations.

When a utility bargains with a service organization to do its spraying, confidence is placed in the contractor's ability to do an efficient job in a workmanlike manner at the lowest possible cost. The utility expects the contractor to be a specialist in his field of endeavor and to adapt his operation to economically control the brush in his territory. The operator should also be continually informed on points of interest and

importance to the utility. To elaborate on this point further, let us first consider equipment.

EQUIPMENT. The contractor is expected to have equipment adapted to the specific job in which he has obligated himself to spray, whether it be low pressure, high pressure, from a roadside boom, or a handboom, whether it may be a gun type or brush type hand boom. It would seem very impractical for three men to spray brush at the rate of one or two miles per day if this area could be sprayed equally as well, with no more danger of damage, by driving perhaps a more expensive unit suitable for covering from 40 to 60 feet in one swath and spray ten or more miles per day. Also, the utility has found from past experience that old worn-out trucks will not be as efficient as newer trucks kept in good mechanical conditon. They fully realize that to be efficient good equipment must be supplied.

PERSONNEL. Personnel has rapidly become one of the heaviest costs on any operation and company policy has a great bearing on the efficiency of the personnel. Spraying is so rapidly expanding that many organizations have been somewhat lax in this field.

A good supervisor will first make it a point to become acquainted with the line superintendent in charge of the area which he is to cover. He will consult with him and go over the company line maps and acquaint himself with local conditions, including company policy, agricultural crops, policy of the road engineer and "hot spots" regarding places where the utility has had unfortunate circumstances previously. Then the supervisor will make a survey of the line, noting specific problems before they arise. During the spraying operation, as well as after it is completed, an effort to secure responsible utility company personnel to ride the line and check the operation regularly. Then management must have the will power to not overcome the temptation of overloading a good supervisor.

Unfortunately to the spray industry, some companies have used poor quality help on their crews. This is a definite hazard to the whole brush spraying industry. A good crew member should be alert and informed on spraying operations. A courteous spray operator may avoid many disagreeable experiences with right of way owners by showing a reasonable amount of courtesy to their property. He should be neat and conscientious about his work. Should anyone ask him what chemical and mixture he is using, he should give them a sensible answer; not like the crew member who replied, "just squirting on some junk that they sent out from the main office". The spray crews must be aware of the danger of drift as well as high pressure.

MIXTURE USED. A successful contractor will use a quality chemical and in most cases a low volatile type chemical is much preferred. The quality chemical will be uniform and formulated by a manufacturer that can send a representative of their research or service department to assist the contractor in recent developments and also service him should any problem arise.

Since one-third or more of the cost of spraying is usually chemical, the utility should have the benefit of the lowest possible price that the contractor will be in a position to quote for a quality product. I have known of a case where a low priced product was short both in pounds of acid per gallon plus the gallonage measure. The mixture used should be specifically designed for foliage, basal or dormant spraying, whichever is being used in that particular location.

REPORTS. Every utility has a very complete bookkeeping and auditing system and are naturally interested in getting prompt reports and billings for all spraying done. Of course, accuracy and detail are very important for cost accounting. It is desirable that the contracting management contact the utility to be certain that they are getting all desired information in a good form.

CONTRACTS. The contractor should supply a good contract form that is flexible enough to fit various operations, yet specific enough to leave as few misunderstandings as possible. However, we have found that utilities are very broad minded and understanding if they are convinced that the contractor is conscientious in his operations.

REGULAR INSPECTION TRIPS. The management of both organizations, along with the spray supervisor and line superintendent will find time well spent if they would frequently cover areas being sprayed as well as areas covered some weeks earlier. While this is being done it gives the supervisor an opportunity to point out unsprayed areas and give reasons for skipping these areas; such as garden spots, legume fields, etc. Such tours give utility personnel a better understanding and often bring out many short cuts that will eventually lower the per unit cost of brush control. At this time the utility companies may be asked for any suggestions that they might have to improve the operation. He may be able to give you a tip from your competitor. Even they sometimes have a good idea.

INSURANCE. The utility naturally will want insurance coverage to protect their organization. This should be cleared with the management of the utility for the amount of coverage desired; and in all cases the certificate of insurance should be in the hands of the utility and approved with them before operations start. The utility has a right and should expect that all claims should be settled to satisfaction if possible as soon as it is feasible to do so.

PUBLIC RELATIONS. A utility may spend many years and dollars to build a good relationship with owners whose private right of way must be obtained or who have adjoining property along a roadside by which a line may run; and then have an incompetent person cause some dollar and cent damage as well as a relations problem that may last well over a generation.

It should be the spray contractor's interest to have the foresight enough to work with various state and local governing bodies as well as wildlife, garden, and conservation groups. Perhaps the criticisms that have arisen from the use of 2,4-D and 2,4,5-T have been largely due to a misunderstanding of a person or groups. This might have been corrected by explaining both points of issue. In our areas we found that the wild-life group was most interested in wild plum and sumac. Since neither of these grow more than four or five tall it was mutually agreed that we not spray these two species if they were not contaminated with taller plants.

ECONOMICS. Brush control has been very costly to most utilities. Therefore, they are very price conscious and want to spread the brush control dollar as far as possible. This again takes good, efficient equipment, operated by competent labor who will apply "just enough" chemical to give a good kill. Again, the utility company realizes that good trucks and sprayers, both of which are standardized, keep break-downs to a minimum. The tanks should be large enough to carry enough of the mixture to run as long as possible without impairing the maneuverability of the unit.

Practical research is important with new chemicals and new types of equipment to cut down on man hours and expedite application as much as possible. The oc type of nozzle and the mist blower are two types of equipment that fall into this

category.

LONG PERIOD OF TIME TYPE PLANNING. The service organization should present to the utility a three, five, or ten year program with estimated cost of brush control. This should include the number of times of spraying, the cost of first application, second, etc., and the time of year to spray different types of brush. For instance, large brush or trees could be sprayed more satisfactorily in basal or dormant spraying while the foliage spraying is better adapted to the smaller brush. Also, the degree of kill should be estimated on the various types of application so that the utility would know what to expect.

In conclusion, a good service organization will give the customer a high degree of kill at the lowest per unit cost and still maintain good public relations.

CHEMICAL BRUSH CONTROL ALONG TELEPHONE LINES IN IOWA

T.J. Sullivan, Des Moines, Iowa.

As you all know, Iowa is the State where the tall corn grows. It is also the state where woody brush grows tall, and wide, along the roadsides under our telephone lines. The many species of native soft woody brush, and the imported osage hedge, are fed by the rich soil and abundant rainfall, and grow rapidly into the telephone lines in two to three years.

Of the 42 thousand farm telephones, over 11 thousand are served from 80 small community dial offices. As the wire lines serving these rural telephones become enveloped, the wind blown brush causes grounding, crossing and shorting of the wires. Such wire troubles cause dial impulses to be sent to the dial office, impairing the service on these lines. When the volume and frequency of such trouble is sufficiently sever, the local dial system could be interrupted for all telephones in that exchange. Long distance circuits of today carry two to a dozen talking circuits over a pair of wires, and the associated complex terminating equipment. Such circuits are even more susceptible to service impairment by brush and tree troubles.

In Iowa, we have some 21 thousand miles of pole line carrying long distance and-or farm telephone lines. While many sections of these pole lines are free from brush, it is estimated that more than half of this mileage has more or less volunteer and scrub growth along its route. The control of this brush and the periodic trimming of shade trees, have posed the major problem in the Maintenance of good service over these wire lines, and has required more than half of the maintenance expenditure for this class of plant.

Prior to the advent of herbicides, there seemed to be no method for brush control other than by the laborious, time-consuming hand-cutting process. From our point of view, this method is now about obsolete due to the high costs and the necessity of repeating the job over and over again within two to five-year periods. As herbicides began to appear on the market in 1945 and 1946, our field maintenance forces took the initiative in their trial use, with the hope of eliminating this hard manual labor... brush cutting. The results of these experiments were so encouraging that by 1947, we started in earnest to extend the mileage of chemical treatment of brush.

During the past six years, our annual programs have covered the spraying of some 25 hundred to four thousand miles of route line at a cost of 50 to 75 thousand dollars. Many sections of line have now been resprayed two to four times. With an estimated average 90 percent kill, the brush along these lines so treated can now be considered under control, and will need further treatment only about every two years to maintain that control. The greater portion of our lines is along roadsides, and this makes for easy spraying operations. We estimate that these brush control programs are being accomplished at about one-third of the cost of hand-cutting.

Quite generally, these brush control programs have consisted of summer spot selective foliage spraying of only the troublesome woody brush. For this purpose, we use a 50-50 mixture of 2,4-D and 2,4,5-T... Four pounds of low volatile ester in 100 gallons of water. During the past year, basal and stem spraying were employed on some ten percent of our mileage, using an oil carrier. The results were about equal to those of foliage spraying for soft woods, and somewhat better on the hard woods and more resistant brush. We plan to explore this method further, and both methods of application should help to balance the work load for the contractor's forces throughout the year.

Initially, our company personnel carried out the actual brush spraying work with our own sprayers. Shortly thereafter, commercial applicators entered the field, and for the past few years, all our brush spraying work has been performed by these contractors. In carrying out our programs, these contractors and we, ourselves, work very closely with the County Weed Commisioners and the State Highway Department Engineers...As to methods and procedures that will merit public acceptance. We have also sought the advice and council of our good friend, Dr. E.P. Sylwester, Extension Plant Pathologist and Botanist at Iowa State College. Dr. Sylwester makes annual inspection tours with us... and his valuable technical assistance kept us from learning the hard way, while his personal efforts in public education and publicity have created a sound understanding among both farm and town groups, of the objective benefits of weed and brush control...this following some serious public resentment. We are very grateful to Dr. Sylwester for helping all of us maintain and expand the very important public relations so necessary in brush control work.

As the methods, techniques and results of brush spraying took definite form, the Bell System issued field practices to all Bell Companies covering all phases of chemical brush control. This material and the bulletins written by Dr. Sylwester constitute our field operating practices.

In reviewing our pioneering work of the past years, and looking ahead to the future to what a utility company can expect from a planned chemical brush control program, we see the development of a new labor-saving procedure providing such benefits as:

1. A better and more reliable public service because interference with plant facilities by useless brush is reduced to a minimum.

2. Reduce cost of providing continually improving public service.

3. Safer and more sightly public roads dedicated to transportation, and the transmission of communication and electric power.

4. With so many favorable and so few unfavorable factors in chemical brush control, there seems little question as to its continued place in the maintenance of utility pole line routes.

CHEMICAL WEED CONTROL IN PEAS.

J.C.M. L'Arrivee, University of Manitoba.

A research program to satisfy the demand for reliable chemical weed control information in canning peas was initiated at the University of Manitoba in 1951.

The generally accepted chemical weed control practice in peas produced in Manitoba has been post-emergence application of Sinox at 2½ to 3 qt./A in 80 gal. of water. The high volume rate for effective application of this chemical makes this operation costly and laborious. Therefore a weedicide which could be applied either as a dust or in a low volume spray form would be of much value. To investigate the possibilities of weedicides recommended for use in peas and found promising in other areas an experiment was carried out consisting of the following treatments:

MCP, sodium salt, at 1, 2 and 3 lb./A. was applied pre-emergently. Post-emergent treatments consisted of Sinox at 1½, 2½ and 3½ qt./A. in 80 gal. of water; KCNO at 8, 16 and 24 lb/A., and $NaHCN_2$ at 16, 32 and 48 lb/A. in 50 gal. of water. Two varieties of canning peas, Pacemaker and Early Perfection, were used with treatments replicated four times with each variety. Yield per plot was recorded for both pulled weeds and shelled peas.

The 1951 experiment was free from any apparent disturbing influence and the following results were obtained: Data on pea yields indicated that there was no significant difference between chemicals. Differences caused by the different rates, however, were highly significant.

From Table 1 it is seen that $NaHCN_2$ at 48 lb/A. injured the peas sufficiently to cause a highly significant yield when compared to the no treatment check. Some injury was also observed, due to the highest rate of KCNO but it caused no significant yield reduction.

Table 1.

Average yield of peas in lbs. per treatment for 1951 rates.

Chemical	0	1	2	3	C
MCP	8.55	8.56	8.52	8.96	9.21
Sinox	7.90	9.20	8.96	7.82	9.05
KCNO	8.41	8.62	8.92	7.69	8.59
$NaHCN_2$	8.86	8.47	8.10	7.55	9.45
Average	8.43	8.72	8.62	8.00	9.07

L.S.D. for rates within the same chemical for 5% significance - .95
L.S.D. for rates within the same chemical for 1% significance - 1.26

The analysis of variance on weeds indicated that the differences between chemicals and rates were significant at the 5% and 1% level respectively. Table 11 shows the average weight of weeds per treatment for the eight replications. This table shows that MCP was the most effective weedicide with Sinox in second place. The predominant weeds were red root pigweed Amaranthus retroflexus, wild buckwheat Polygonum convolvulus, green foxtail Setaria viridis, stinkweed Thlaspi arvense, and lamb's quarters Chenopodium album.

Table 11.

Average yield of weeds in lbs. per treatment, 1951 rates.

Chemical	0	1	2	3
MCP	7.31	1.76	.91	.96
Sinox	7.30	2.52	2.61	2.52
KCNO	7.29	5.01	3.45	3.11
$NaHCN_2$	12.14	6.95	3.82	3.97
Average	8.51	4.06	2.70	2.64

L.S.D. for rates within the same chemical for 5% significance - 3.68
L.S.D. for rates within the same chemical for 1% significance - 4.90

The analysis of variance on sugar readings revealed that the differences caused by treatments were not significant.

In 1952, shortly after the application of the pre-emergence treatment of MCP excessive rains caused considerable injury to the crop. The unseasonal and obnormally high moisture conditions prevailed until the time of application of the post-emergence treatments. Weed germination became active only after the application of these weedicides. Due to these facts only two replications for each variety were worthy of being harvested.

The statistical analysis on pea yields revealed that only the differences caused by the different rates were highly significant. Referring to Table 111 it is seen that plots treated with $NaHCN_2$ at 48 lb/A. produced significantly lower yields than the checks.

Table 111.

Average yield of peas in lbs. per treatment for 1952 rates.

Chemical	0	1	2	3
MCP	2.47	2.15	1.69	1.38
Sinox	2.35	2.63	2.34	2.36
KCNO	2.40	2.29	2.16	2.09
$NaHCN_2$	2.43	2.25	2.09	1.97
Average	2.41	2.33	2.07	1.95

L.S.D. for rates with checks at 5% - .46

Also it will be noted that the 2 and 3 lb/A. treatment of MCP resulted in lower yields.

The analysis of variance for weed weights gave similar results to those of 1951. Table 1V shows the average weights of weeds in pounds for the different treatments. MCP gave a significantly lower average weight of weeds that the other three chemicals.

The predominant weeds were red root pigweed Amaranthus retroflexus, lamb's quarters Chenopodium album, maple-leaved goosefoot Chenopodium hybridum, stinkweed Thlaspi arvense, and barnyard grass Echinichloa crus-galli.

Table IV.

Average yield of weeds in lbs. per treatment for 1952 rates.

Chemical	0	1	2	3
MCP	6.00	1.30	.37	.25
Sinox	7.75	8.56	6.06	3.50
KCNO	5.96	4.12	2.94	1.65
$NaHCN_2$	6.90	6.50	3.25	2.81
Average	6.65	5.12	3.15	2.05

L.S.D. for rates with checks at 5% significance - .55

In addition to this experiment screening tests were carried out during the two years. These tests included a number of weedicides which showed some value in controlling weeds with relatively little injury, if any, to the peas. Pre-emergence treatment with endothal gave excellent control of Setaria viridis. Good control of broad-leaved annual weeds was obtained with naphthyl phthalamic acid, SES, MH, DNOSBP, and PCP, sodium salt.

The post-emergence application of MCP (sodium salt) at 1/4, 1/3, 1/2, 2/3, 3/4 and 1 lb/A. effectively controlled the weeds but the three higher rates damaged the peas and delayed their maturity. MH when applied post-emergently at 6 and 9 lb./A. did not harm the peas. However, some of the weeds, in particular Thlaspi arvense seemed to have been rendered sterile.

Summary

Under the conditions of these experiments MCP was rated the most effective weedicide with Sinox in second place. Due to the low volume of spray required and apparent relative tolerance of the pea plant, as well as the comparative ease of handling this chemical seems to offer real promise. MCP (sodium salt) applied as low as 1/4 lb/A. post-emergently or at 1 lb/A. pre-emergently effectively controlled most broad-leaved annual weeds. Rates higher than these were injurious to peas in some cases.

Sinox appeared about equal or slightly better than the two other contact herbicides, KCNO and $NaHCN_2$.

THE EFFECT OF WEED COMPETITION ON THE GROWTH AND DEVELOPMENT OF CARROTS.

C.A. Shadbolt and L.G. Holm, University of Wisconsin.

A number of experiments have been reported on the effect of weed competition upon agronomic crops. However there is little known work of this nature upon row crops where the cost of production is much higher. The purpose of this preliminary study was to obtain some quantitative information on the effects of weed competition upon carrots at various stages of development. This type of information will be very useful for the determination of the amount of weed control required to make the use of a chemical profitable, as well as in the determination of losses resulting from weed competition.

Our experiment was conducted on organic soil in completely randomized and replicated blocks. Four levels of weed population were used in the experiment: 100%, 50%, 20%, and 0% of the normal weed stand. The 100% plots contained 20 weeds per square foot, and the 50 and 20% stands were thinned down to 10 and 4 weeds per square foot respectively. These levels were maintained by removal of all the new weed seedlings which appeared. The weeds were left in an 8 inch band over the row, and the area between the rows was clean cultivated. The predominant weed was redroot pigweed (Amaranthus retroflexus), with smaller numbers of Lady's thumb (Polygonum Persicaria).

The weeds were allowed to remain in the plots for various lengths of time, viz. 4, 5½, and 7 weeks after emergence of the carrots. At each level of weed competition, and at the dates designated above, the weeds and the carrots were harvested from one plot, while in a similar plot the weeds were harvested at these dates while the carrots were allowed to go on to maturity. The total weight of carrots and weeds, and the total number of carrots was recorded from each plot, whereas a random sample was used for fresh and dry weights of roots and tops, length of root and top, and diameter of root.

The yields of carrots, expressed as the percent reduction from a weed free check, and taken at the time of weeding, are shown in Table 1.

Table 1.

The effect of weed competition on yield of carrots in the early stages of development.

Weed population	Percent reduction in yield from a weed free check when harvested at:		
	4 weeks	5½ weeks	7 weeks
20% stand	24%	50%	47%
50% stand	20%	63	80

Table 2 shows the percent reduction in yield when the competition was removed and the carrots allowed to grow to maturity.

Table 2.

The effect of weed competition on yield of mature carrots.

Weed population	Percent reduction in yield when plots were weeded at:		
	4 weeks	5½ weeks	7 weeks
20% stand	19%	27%	36%
50% stand	22	55	57

It can be seen from Tables 1 and 2 that the percent yield reduction when taken at maturity is less than when taken at the time of weeding. This indicates that there was some recovery of the carrots after the weeds were removed from the plots. Those carrots which were only slightly set back by a moderate amount of competition showed very slight recovery when the competition was removed. On the other hand, those which received a severe set back from early weed competition showed an enhanced rate of growth after the competition had been removed. In other words, when based upon yield, the greatest amount of recovery was made by plants which suffered the greatest amount of competition early in the season.

The diameter of the carrot roots at the end of the period of competition (Table 3), showed a very marked reduction when compared to roots which had been grown in weed free plots. This tendency to limit increase in diameter was more pronounced at the higher levels of weed competition.

Table 3.

The effect of weed competition on the diameter of carrot roots during the early stages of development.

Weed population	Time of harvest in weeks after emergence:		
	4 weeks	5½ weeks	7 weeks
weed free (0%)	2.7 mm.	7.5 mm.	15.4 mm.
20% stand	1.9	4.7	10.0
50% stand	1.8	3.5	5.7
100% stand	1.7		

The size of the carrots grown at all the levels of competition, when studied at maturity (Table 4) still showed a considerable reduction in diameter. Thus, as in the case of yield at maturity, the carrots were not able to recover completely from their initial set back after the competition was removed.

Table 4.

The effect of weed competition on the diameter of carrot roots at maturity.

Weed population	Time of weed removal in weeks after emergence:		
	4 weeks	5½ weeks	7 weeks
weed free (0%)	39.5 mm.	39.5 mm.	39.5 mm.
20% stand	35.2	31.7	32.3
50% stand	34.5	28.6	28.3
100% stand	32.5		

The period between 4 and 5½ weeks after emergence appeared to be the most critical in that the greatest rate of reduction in yield occurred between those dates. The rate of reduction in yield tended to level off after that time. This can be accounted for, in part, by assuming that as the weeds developed, they began to compete with each other, after which time there was proportionately less total competition with the carrots. This is borne out by a study of the weights of weeds taken from the plots at the time of weeding, and which are presented in Table 5.

Table 5.

Weight of weeds produced by several levels of weed populations.

Weed population	Time when weed weights taken, in weeks after emergence:		
	4 weeks	5½ weeks	7 weeks
20% stand	2.5 lbs.	11.5 lbs.	21.7 lbs.
50% stand	4.3	16.4	19.2
100% stand	5.3		

The data indicates that under conditions of increasing competition a point is reached where there is a maximum amount of plant material which will be supported by a given land area.

The index of carrot shape as given in Table 6, is a ratio of the length of the root to the diameter of the root. Therefore a low index number indicates short and thick carrots, whereas a high index number means long and thin carrots.

Table 6.

The effect of weed competition on the shape of carrot roots.

Weed population	Shape of carrot roots at harvest time when weeds remained in plots for:		
	4 weeks	5½ weeks	7 weeks
weed free	2.06	2.06	2.06
20% stand	2.03	2.37	2.54
50% stand	2.18	2.53	2.63
100% stand	2.24		

$$\text{Shape} = \frac{\text{length of carrot root}}{\text{diameter of carrot root}}$$

The carrots receiving weed competition were longer and thinner than those receiving no competition. Carrot shape may be a function of the stage of development of the carrots, as it may be assumed that those carrots which were severely set back were less mature than those receiving no competition.

One of the most surprising facts brought out by this investigation was the marked reduction in carrot stands with increasing competition from weeds (Table 7).

Table 7.

The effect of weed competition on carrot stands.

Weed population	The number of carrots at harvest time when weeds remained in plots for:		
	4 weeks	5½ weeks	7 weeks
weed free	90.2	90.2	90.2
20% stand	87.5	86.7	76.5
50% stand	82.2	70.7	72.2
100% stand	72.5		

It has not been generally appreciated that a portion of the crop stand may actually be eliminated by such low levels of weed competition at the early stages of growth and development.

In experiments conducted at the University of Wisconsin, it was clearly evident that many quantitative factors may suffer as a result of weed competition during the early stages of crop development. Yield, the all important criterion from a commercial point of view, was seriously reduced at all levels of competition. Some of you may suggest that this reduction in yield may be overcome by delaying the harvest for two or three weeks. In the commercial production of many crops, however, this procedure could be very undesirable. Futhermore, it is very clear from our work that once diameter, shape, or stand are adversely affected during early stages of growth, there is little recovery from this injury.

CMU AS A HERBICIDE FOR HORTICULTURAL CROPS.

D.D. Hemphill, University of Missouri

Preliminary trials in 1951 established that under our conditions CMU was an effective herbicide for a number of the most troublesome weed species, that it had excellent residual properties and that crops differed in their tolerance to this chemical. During the 1952 season, 3-(p-chlorophenyl)-1, 1-dimethylurea (CMU) was tested for possible herbicidal

use in a number of horticultural crops.

In a grape vineyard of mixed varieties CMU was applied in an eighteen inch band beneath the trellis at the rate of one pound per acre in 25 gallons of water. The spraved areas remained practically free of all weed growth for six weeks after which time foxtail (Setaria sps.) and crabgrass (Digitaria sanguinalis) seedlings began to appear. These weeds showed tip burn and stunting. It was late in the summer before weeds were present in sufficient numbers to seriously compete with the grapes. Two applications would most likely have given practical control of the weeds. There was no evidence of injury to the grape vines from the single application.

In gladiolus cormels grown for size increase CMU was used pre-emergence ½ pound per acre on May 4 and as a foliage spray 1 pound per acre on July 30. No visible injury resulted from the pre-emergence treatment, but this rate was not sufficient to control the crabgrass and foxtail which were the primary weeds. Serious weed competition occurred during the first month which may have depressed yields. No injury was visible from the foliage application on July 30 and most weeds were controlled until lste October when the cormels were dug. Yields of CMU plots were 80 per cent of that of control plots which were hand weeded weekly.

A pre-emergence application of CMU 1 pound per acre gave excellent control of weeds in peas, Wando variety, grown on a silt loam soil. The plants in CMU plots were more vigorous in appearance than those of control plots or plots treated with other chemicals and this vigor was reflected in higher yields. Compared with four other chemicals CMU was the most satisfactory herbicide for use in peas in 1952.

Sweet corn, Golden Cross Bantam variety, grown on a heavy silt loam soil appeared tolerant to a pre-emergence application of 1 pound of CMU. Excellent control of weeds was obtained and there was no visible injury to the corn plants. Yields were comparable to that of control plots.

Snap beans were injured by a pre-emergence application of ½ pound per acre. Stand and yield were reduced. Many plants exhibited marginal leaf burn and remained stunted throughout the growing season. This rate did not give satisfactory control of crabgrass and foxtail which were the primary weeds.

Cantaloupes, cucumbers, squash and watermelons appear very sensitive to CMU. A pre-emergence application of 1 pound per acre killed a large percentage of the seedlings as they emerged and stunted others. The yield of squash, which exhibited the greatest tolerance, was reduced approximately 50 per cent.

The results of these experiments indicate that the excellent herbicidal and residual properties of CMU may possibly be utilized for control of weeds in certain Horticultural Crops. Corn, gladioli, grapes and peas showed considerable tolerance to concentrations of CMU which gave satisfactory control of annual broad-leaved and "grassy" weeds.

THE CONTROL OF WEEDS IN ONIONS WITH PRE-EMERGENCE SPRAYS.

R.E. Nylund, University of Minnesota.

The research reports of the North Central Weed Control Conference for the past six years (1947-1952) include 45 abstracts dealing with studies on the pre-emergence control of weeds in onions. Approximately 30 chemicals have been tried, most at several rates applied at various times prior to crop plant emergence, to several varieties of onions, and on several soil types.

As might be expected when one considers the complex of environmental factors, weed species, and crop varieties involved, none of the chemicals have proven to be completely effective as weedicides and at the same time completely non-toxic to onion seedlings. The dinitros, the phenolic compounds, SES, endothal, sodium isopropyl xanthate, TCA, and xanthogen disulphide have, in general, been toxic to onions, when applied at rates which would control weeds. Certain other compounds have appeared to be more promising as pre-emergence weedicides for onions. These are: 2,4D, Stoddard solvent, KCNO, CIPC, and CMU. The results of tests with these herbicides are summarized briefly in Table 1 below.

Table 1.

Summary of effects of various herbicides on weeds and onions (1)

Herbicide applied and per acre rate used:	Number of experiments reporting No crop injury: Fair to good weed control:	Poor weed control:	Crop injury
½-1 lb. 2,4D	16	1	8
40-80 gal. Stoddard solvent.	10	2	2
16-25 lbs. KCNO	7	1	1
2-12 lbs. CIPC	7	0	0
½ - 2 lbs. CMU	15	2	4

(1) Compiled from research reports of the North Central Weed Control Conference, 1947-1952.

2,4D, which has been most widely tested, has been on an effective weedicide in 16 of 25 tests but has caused serious injury to onions in 8 tests and thus must be considered as being unsafe to use on onions. The aromatic oil, Stoddard solvent, has been more consistently effective as a pre-emergence weedicide for onions. Unfortunately, its relatively high cost has tended to discourage its use by growers although some have used Stoddard solvent for several years in spite of this drawback. Potassium cyanate (KCNO) has fairly consistently given good weed control without crops injury. It also has the disadvantage of being quite expensive. Of the more recently introduced herbicides, CIPC and CMU appear to have considerable promise. In seven tests in which it was used at rates of from 2 to 12 pounds, CIPC has given good to excellent control of such common muckland weeds as smartweed (Polygonum persicaria) and purslane (Portulaca cleracea). Unfortunately, CIPC has given poor control of lambsquarters (Chenopodium album) and pigweed (Amaranthus retroflexus). In 21 tests in which CMU was applied at rates of one-half to two pounds per acre, good control of most muckland weeds was obtained in 15 tests, poor control in two tests, and onion injury was reported in four tests.

Another pre-emergence herbicide not listed in Table 1 should also be mentioned. Calcium cyanamid, applied as a dust at 70 to 100 pounds per acre, has been successfully used by growers in Minnesota during the past two years. Apparently very little research on the use of this herbicide has been conducted in the north central region, although it has been tested extensively in the eastern states.

At the Minnesota Agricultural Experiment Station, studies on pre-emergence weed control in onions have been conducted since 1948. Table 2 gives the percent weed control obtained during the years 1948-1952 with the herbicides which

have to date appeared to be most satisfactory from the standpoints of weed control, non-toxicity to onions, and ease of application.

Table 2.

Percent weed control in seeded onions resulting from pre-emergence application of the indicated herbicides. (Minnesota Agricultural Experiment Station, 1945-1952).

Herbicide applied and rate per acre:	Percent Weed Control				
	1948:	1949:	1950:	1951:	1952:
80 gal. Stoddard solvent	61	58	86	49	68
16 lbs. KCNO	--	--	92	42	58
20 lbs. KCNO	--	68	97	24 *	59
1 lb. CMU	--	--	--	75	78
2 lbs. CMU	--	--	--	79	82

* Not significantly different from control.

All percentages given, with the one exception indicated, represent statistically significant degrees of weed control as measured by weed counts made two weeks after herbicide applications. In all experiments the herbicides were applied seven to ten days after seeding on muck soil. None of the herbicides reduced stands or yields of onions. As is apparent from Table 2, weed control obtained with any particular herbicide varied considerably from year to year. In 1950, all herbicides used gave a high percentage of weed control. This was probably due to the fact that in 1950 the land was seeded to onions seven days after soil preparation thus allowing greater emergence of weeds prior to herbicide application. In 1951 and 1952 onions were seeded immediately after soil preparation and thus the contact type herbicides (Stoddard solvent and KCNO) were less effective than CMU which has a longer residual effect.

In 1952, a second experiment was conducted to determine the influence of rate and time of application on the effectiveness of CMU as a pre-emergence herbicide for onions. Table 3 gives the percent weed control obtained when ½, 1, and 2 pounds of CMU were applied 0, 3, 6, and 9 days after seeding to onion seeded on two dates. Weed counts were made two weeks after the final herbicide application in each planting.

Table 3.

Percent weed control obtained in two onions plantings by the application of CMU on four dates after seeding.

Herbicide treatment Rate CMU applied	Days after seeding	Percent weed control in Apr. 23 planting	May 6 planting
½	0	41 **	24
½	3	55 **	11
½	6	53 **	22
½	9	63 **	-20
1	0	57 **	51 *
1	3	64 **	44
1	6	64 **	47 *
1	9	75 **	42
2	0	69 **	73 **
2	3	60 **	62 *
2	6	83 **	69 **
2	9	80 **	69 **

* Significant at 5% level.
** Significant at 1% level.

Two interesting results are apparent in Table 3: (1) CMU was much less effective in controlling weeds in the late planting than in the early planting, particularly cularly when used at the lower rates, and (2) delaying CMU application resulted in better weed control in the early planting but not in the late planting. These effects may be at least partly explained on the basis of differences in temperatures and precipitation during the six-day periods following herbicide applications in the two plantings. These data are given in Table 4.

Table 4.

Mean temperatures and precipitation during the six-day periods following CMU applications in two plantings of onions.

Days after seeding CMU applied	Mean temp. for 6-days following CMU application		Total rainfall during 6 days following CMU appl.	
	Apr. 23 planting: degrees F.	May 6 planting: degrees F.	Apr. 23 planting: inches	May 6 planting: inches
0	61	50	0	0.64
3	68	51	0	0.70
6	69	54	0	0.54
9	61	54	0.48	0

Temperatures during the six-day periods following CMU applications in the early planting were high relative to the temperatures during comparable periods in the late planting. These high temperatures undoubtedly caused rapid germination and growth of weed seedlings and thus could account for the greater weed control obtained by all treatments in the early planting. Also, the rainfall during the six days following the final herbicide application in the early planting, by its effect on the penetration of CMU into the soil and also on increasing weed seed germination could account for the relatively greater weed control obtained by the delayed CMU applications. In contrast, the relatively low temperatures and uniform distribution of rainfall following each herbicide application in the late planting could account for the generally poorer weed control and also for the similarity of weed control under all dates of treatment. Under conditions of low temperature (and thus slower weed germination and growth) ½ pound of CMU was considerably less effective in controlling weeds than when temperatures were higher.

In summary, from the standpoint of toxicity to weeds and non-toxicity to onions, three herbicides appear to be outstanding for use as pre-emergence weedicides in onions. These are: Stoddard solvent, KCNO, and CMU. The former two being contact killers are most effective when seeding is delayed or when growing conditons are such that rapid emergence of weeds occurs prior to herbicide application. The latter, CMU, having a longer residual effect, appears to be more effective than the contact herbicides under conditions which result in delayed weed germination and slower weed growth. (Paper No. 2938 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.)

HERBICIDAL MIXTURES FOR WEED CONTROL IN VEGETABLE CROPS.

G.F. Warren and J.E. Larson, Purdue University, Indiana.

In the control of woody plants and the spraying of railroad rights-of-way, it was early recognized that a combination of two or more herbicides would control more plant species than a single chemical. Only recently, however, have

such combinations been used to selectively control weeds in crop plants. A mixture of TCA with 2,4-D or MCP has been recommended to control both annual broadleaved and grassy weeds in flax and a few vegetable crops. The extension of combination treatments to other vegetable crops was delayed by lack of a sufficient number of herbicides having different selectivities. However, we now have several chemicals that will control certain weeds without reducing the yield of one or more of these crops. The need for herbicide combinations is greatest in those situations where many different weed species are commonly present in the fields used for a given crop.

The question often arises as to the compatibility of various mixtures. We have found in most cases that this is not a problem. The one notable exception is mixtures that involve a wettable powder and an oil formulation of some other herbicide. In such mixtures the wettable powder may precipitate out of the spray solution. However, formulations of the two chemicals that are compatible can usually be manufactured. In general, any two herbicides when applied as a mixture have given about the kind of results one would expect if he added the weed control obtained when each was used singley. A weed or crop that is highly resistant to each herbicide has ordinarily been uninjured by a mixture of the two.

We have had excellent success in the use of mixtures of herbicides for pre-emergence weed control in direct-seeded tomatoes. In Indiana most of the broadleaved weeds come up before the tomatoes and can be killed with certain contact weed killers. On the other hand, only a small percentage of the annual grasses usually emerge before the tomatoes, but it was found that these could be controlled with light applications of TCA. Combination treatments of TCA with an appropriate contact herbicide were found to be highly effective in controlling both the broadleaved and grassy weeds when applied about two days before tomato emergence. One of the best treatments was sodium TCA, at the rate of 3 pounds of acid equivalent per acre, and a PCP formulation in an oil carrier at the rate of 2 pounds of PCP per acre. The PCP formulation is emulsified in the water used for spraying, while the sodium TCA dissolves in the water.

Another herbicide mixture has given promising results as a pre-emergence treatment for onions grown on much soil. This is 75 gallons of Stoddard solvent per acre in which 12 pounds of CIPC has been dissolved. (There is evidence that the rate of application can be reduced without greatly affecting the results.) It is applied just before the onions emerge. The Stoddard solvent kills by contact the weeds that come up before the onions. Among these early weeds are most of the lamb's quarters and many of the pigweed plants that will eventually germinate during the season. This is an important feature since lamb's quarters is highly resistant and pigweed moderately resistant to CIPC. On the other side, CIPC has a long residual effect and gives good control of most of the later germinating species including purslane, and annual grasses.

These are only two examples of selective herbicide combinations that have shown promise in vegetable crops. There are many others and with the introduction of new weed killers each year, the number of possibilities will increase rapidly.

CONTROL OF WILD OATS AND VOLUNTEER GRAIN IN SUGAR BEETS WITH IPC

R.T. Nelson, Longmont, Colorado

Tests conducted in 1952 and discussed herein was designed to evaluate (1) the effectiveness of specified treatments in eliminating large (and small) seeded annual grass weeds from commercial plantings of sugar beets, and (2) tolerance of the sugar beet crop to each treatment by comparison with untreated areas.

Results obtained at Longmont, Colorado, in three different tests conducted in 1951, using IPC (isopropyl n-phenyl carbamate) as a pre-planting application and incorporating it with the soil, were highly encouraging. Results in one test at Longmont in 1951 using CIPC n-(3-chlorophenyl) isopropyl carbamate in similar manner also proved effective in controlling wild oats and volunteer grain.

Based on previous local experience, four treatments were proposed for testing in areas plagued by wild oat and volunteer grain in sugar beet production, within territories served by The Great Western Sugar Company. These treatments, expressed as rates of active ingredient, were:

1) IPC emulsifiable, three pounds per acre.
2) IPC emulsifiable, six pounds per acre.
3) CIPC emulsifiable, three pounds per acre.
4) CIPC emulsifiable, six pounds per acre.

The above treatments were applied in ten gallons aqueous emulsion per acre with a low pressure weed sprayer. Each treated plot was one acre in size and constituted a strip throught the field. Adjacent to each treated plot was left an untreated buffer (check) strip.

Among sugar beet contracts fields were selected by company fieldmen for testing based on the fields' history regarding foulness from wild oats or volunteer grain, or both. The number and location of fields selected for test fields were: Three at Billings, Montana; three at Lovell, Wyoming; two at Wheatland, Wyoming; three at Frot Collins, Colorado; three at Longmont, Colorado; one at Fort Lupton, Colorado.

All tests were cooperative between The Grower; Columbia-Southern Chemical Corporation and California-Spray Chemical Corporation, manufacturer and formulator, respectively, of herbicides used: and The Great Western Sugar Company. At Billings the Montana Agricultural Experiment Station assisted in conducting the tests presently described and also extended their investigations; a detailed report of which will not be made herein.

The application of the herbicides was supervised in every case but other cultural practices were at the discretion of the grower. Thus, there were many deviations from the planned procedure which was to:

(1) Partially prepare the seed-bed so that there would be no gross unevenness of the surface.
(2) Spray the barren field with the prescribed treatments and follow immediately with a double discing to incorporate the chemical with the surface four inches of soil.
(3) Complete seed-bed preparation and plant sugar beets.
(4) Irrigate if necessary.

The immediate discing following application of IPC would seem especially important under conditions of dry soil and intense sunlight in view of results recently reported by Anderson, Linder and Mitchell (1). In laboratory studies they found 80% of IPC evaporated within 24 hours at temperatures of 85-88°F., and that CIPC evaporated even faster.

Results

Control of grasses - The results of the tests as a whole were good (see accompanying tabulation). In eight of the fifteen tests all treatments gave highly satisfactory control of wild oats and volunteer grain. In three additional tests only the six pound rates gave satisfactory control. In the remaining four tests all treatments were classified as unsatisfactory. Of the four tests in the unsatisfactory group three fields (at Lovell) thus classified were merely harrowed after the chemical was applied. Regarding the one remaining field (at Wheatland) there was an unusually long dry period before and after application of IPC and irrigation was not employed to make germination condititons favorable. In spite of the fact that on this test discing was performed immediately after spraying very little, if any, control could be observed in the case of the IPC treatments. Some control was obtained with the CIPC treatments which generally is proclaimed, and certainly demonstrated here, to have a longer residual action when incorporated with the soil.

Number and ratings of tests for control of wild oats and volunteer grain, by locations.

Location	Number of Tests ratings *		
	A	B	U
Billings, Mont.	1	2	0
Lovell, Wyo.	0	0	3
Wheatland, Wyo.	0	1	1
Fort Collins, Colo.	3	0	0
Longmont,Colo.	3	0	0
Fort Lupton, Colo.	1	0	0

*A - Satisfactory control from all four treatments.
B - Satisfactory control from only the 6 lb/A rate.
U - Unsatisfactory control from all four treatments.

Actual counts of control were not taken. Records of control are recorded in photographs. As a guide to the reader any treatment considered satisfactory gave an estimated reduction of at least 75 percent in stand of wild oats and volunteer grain (barley or tame oats) and an estimated reduction of more than 90 percent in gross weight of such foul growth.

In the tests reported here there were none that gave satisfactory control of small seeded grasses (Setaria or Echinochloa) which germinate later in the season as compared with wild oats or small grains.

Residual effects of herbicides - Plantings of spring wheat, wild oats, oats, corn, barley, and sugar beets made in soil collected to a depth of three inches from treated field areas 24 days (April 8 to May 2) after treatment showed no deleterious effects from treatments of either three or six pounds IPC. The three pound rate of CIPC showed some deleterious effect on all crops except corn and sugar beets, while the six pound rate of CIPC had a deleterious effect on all crops including corn and sugar beets. The effect of the residual CIPC on corn and sugar beets at this date was a matter of a reduction in vigor rather than stand.

An adjacent area of the field used for residaul studies mentioned above was sprayed May 2, at three pounds IPC per acre and double disced. Immediately soil was collected from the surface three inches for planting to crops as above. In this case there was no emergence of wheat, wild oats, oats and barley, approximately 50 percent emergence of corn and negligible effect on sugar beets.

Crop tolerance and yield - Pre-thinning stand counts of sugar beets taken on two fields having favorable germination conditions showed no material difference in stand between check and treatments 1-3. However, treatment 4 (CIPC 6 lb/A) showed a reduction of approximately 50 percent compared with check area or other treatments. Mean counts of sugar beets for 100 inches of row for one field made at a very early date (before emergence was complete) for the respective areas were as follows:

IPC 3 pounds per acre	23; adjacent check	29.
IPC 6 pounds per acre	13; adjacent check	31.
CIPC 3 pounds per acre	12; adjacent check	29.
CIPC 6 pounds per acre	6; adjacent check	26.

The stand counts given bring out the inherent danger of using CIPC on sugar beets. Also, the danger in using without discretion as high a rate as six pounds per acre of IPC.Actually, the post-thinning stands of sugar beets were generally better for the IPC treated plots because of increased efficiency in thinning in the absence of tall grass. This is clarified in harvest results.

Harvest results were taken on three fields; one each in Fort Collins, Longmont, and Fort Lupton factory districts. The locations were used as replications and the results analyzed as a randomized complete block experiment. The results appear in the accompanying table.

Harvest results for various treatments as mean of three locations.

Treatment	Beets per 100 ft. of row	Tons beets per acre	Sugar Percent	Pounds sugar per acre.
Check	80.8	16.93	15.41	5216
IPC, 3lb/A	94.2	17.01	15.42	5253
IPC, 6lb/A	100.7	20.43	14.96	6166
CIPC,3lb/A	71.5	15.42	16.12	4953
CIPC,6lb/A	71.2	15.01	15.78	4718
General Mean	83.66	16.98	15.54	5261
C.V. (%)	12.16	16.95	2.55	5.88
LSD 5% pt.	19.15	NS*	NS	NS

*Differences not significant by F test at 5% level.

The harvest results presented point particularly toward differences existing between stands of different treatments. A trend toward increased stand after thinning is indicated where IPC was used. Even though hand thinning and weeding was used, final beet stands were lower where labor had to contend with grass as in the check areas. The CIPC areas were low in stand not because the labor had grass to eliminate, but because of an initial low emergence and survival of beets on the plots.

The usual procedure, if a beet field emerges foul with wild oats or volunteer grain, is for the grower to disc up the field and replant. This procedure shortens the growing season and consequently reduces yield and sugar percentage. A portion of one field replanted approximately one month after the first planting (because of the wild oats hindrance to thinning of first planting) resulted in the following yields and quality of beets as estimated from samples taken in the two portions of the field:

First planting 15.25 tons with 14.25% sugar.
Second planting 12.83 tons with 13.22% sugar.

Of the 15 fields tested there were two other fields in which thinning was not completed on the first planting because of wild oats and volunteer grain on the untreated areas. On the other hand, none of the fields were replanted because of the injurious effects of the herbicides used. However, it was

recognized that on at least three fields beet stands on the CIPC plots were at a critically low level. In all tests seeding rates of segmented sugar beet seed common to the area were used.

Summary and Conclusions

Tests made on 15 fields in six different factory districts during 1952 substantiate previous studies by The Great Western Sugar Company Experiment Station that IPC can be used effectively and with reasonable safety as an aid to the control of wild oats and volunteer grain in fields of these localities planted to sugar beets. The IPC showed merit over CIPC in that sugar beets exhibited greater tolerance to the former. Thoroughly incorporating the IPC with the soil surface either with a disc, or field cultivator, or both, was essential. The soil moisture and temperature were important factors in affecting control. For effective control of wild oats, barley, oats, or wheat germination, conditions for these annual grasses needed to be favorable, at the time, or shortly after the application of the herbicide. Three pounds of IPC per acre was adequate under favorable conditions. Rates up to six pounds IPC per acre increased control of grass under less favorable conditions: however, when the sugar beets germinated before a substantial portion of the IPC applied in a six pound rate had dissipated a noticeable delay in emergence of sugar beets occurred.

CONTROL OF WEEDS IN CANNING PEAS WITH MCP

K.P. Buchholtz, University of Wisconsin.

Prior to 1949 casual observations had indicated that canning peas were not killed by accidental treatment with light rates of 2,4-D. This suggested that the phenoxy herbicides might be of value for control of weeds in this crop. If the peas possessed sufficient tolerance herbicides of this type could be used to control Canada thistles, mustard, lambsquarters and other broad-leaved weeds in this crop.

In 1949 and following years plots 3 by 12 feet or 6 by 12 feet in size were established in fields of peas sown with a drill having a 6-inch row spacing. Seeding rates were about 240 lbs/A and attempts were made to approximate commercial cultural practices. Peas of the Alaska variety and those of the Perfection type were used. Plots were free of broad-leaved weeds or nearly so in all instances. The application of the herbicides was made either by hand sprayers or by a bicycle mounted sprayer using water equal to 20 or 40 gallons per acre. At canning stage a sample of the plants from each plots were pulled, the pods picked and shelled. Weights of shelled peas were obtained and tenderometer readings were secured in most cases. In one instance the peas could not be harvested at the canning stage and were allowed to mature.

Initial trials showed that MCP was noticeably less toxic to the peas than was 2,4-D. It was also noted that the sodium salt and amine preparations of MCP were much less toxic to the peas than the ester preparation of this material. As expected the injury or reduction in yield became more noticeable on plots treated with the higher rates. The pea plants showed a marked response to even the lowest rates of MCP application. Leaf epinasty, stem budding and stunting were evident. These responses were transitory, however, and after 7 to 10 days the plants showed little evidence of the treatment. A summary of the results obtained is shown in the two following tables.

Effect of MCP and 2,4-D preparations on shelled pea yields and tenderometer readings.

Material	Rate lbs/A	Shelled peas lbs/A	Tenderometer readings
MCP Amine	0.125	4129	124
	0.25	3720	110
	0.50	2993	90
MCP Na-salt	0.125	4111	132
	0.25	3998	110
	0.50	2617	90
MCP Ester	0.125	2809	88
	0.25	2788	79
	0.50	1684	76
2,4-D Amine	0.125	4194	126
	0.25	3081	114
	0.50	1913	82
Check	---	4192	131

The reduction in yield of shelled peas is associated with a low tenderometer reading. This indicates a delay in maturity of plants from treated plots and suggests that the reduction in yields would be reduced if harvests were taken at comparable stages of maturity.

The most beneficial results from the use of MCP for weed control will be obtained when the weeds are eliminated or checked in the seedlings stage before they can compete seriously with the peas. Plots of peas were sprayed in 1951 and 1952 at several stages of growth varying from the time they were 2 inches tall until the full bloom stage to determine if they varied in sensitivity during the season. The results indicate that the peas withstand the application of the herbicide best when from 6 to 12 inches in height. Treatment soon after emergence probably results in slow recovery of the peas and consequently reduces yields. Treatment near the bud and bloom stages possibly reduces yields by causing a reduced number of pods to develop. The apparent peak in tolerance of the pea plants at the 6-inch stage coincides closely with the most favorable time for treating weeds in this crop.

Average yields of peas from plots treated with 0.125, 0.25 and 0.50 lbs/A MCP at different growth stages.

Growth Stage	1951 Dry peas lbs/A	1952 Shelled peas lbs/A
2 in. high	---	3017
6 in. high	809	3871
12 in. high	818	3465
Early bud	605	---
Early bloom	570	---
Full bloom	723	---
Check	870	3807

The range of tolerance of peas to MCP is not great. Therefore the rate of application must be controlled closely. Ordinarily it appears as though 0.25 lbs./A is the greatest application that can be depended upon not to give noticeable reductions in yields. The application of 0.50 lbs/A may frequently, but not always, give reductions in yield. Since the results described were taken from weed-free fields it can be expected that treatment of fields infested with weeds should result in no yield reduction when the 0.25 lb. rate is used and increases in yields should be expected. The value of the 0.50 lb. application will depend on the weed problem encountered. If Canada thistles are a serious pest the use

of this heavier application will probably be required to prevent the development of thistle buds. If control is obtained some reduction in yield can be tolerated. The following table gives comparisons obtained in five separate trials in which yields of shelled peas were obtained after treatment with 0.125, 0.25 and 0.50 lbs./A of MCP in the amine form.

Average yields of shelled peas from plots treated with MCP when the peas were 6-12 in. high.

Rate Lbs/A	Shelled peas - Lbs/A				
	1949	1950	1951	1952A	1952B
0.125	--	2929	4129	3563	2976
0.25	3639	1946	3739	3760	3032
0.50	--	1435	2993	3679	2736
Check	3819	2687	4192	3807	2656

PHYSIOLOGICAL STUDIES ON THE BEHAVIOR OF TCA IN VEGETABLE CROPS AND SOILS

T.W. Tibbitts and L.C. Holm, University of Wisconsin

The recent acceptance of TCA as one of our important compounds for controlling weeds has prompted several workers to investigate the effects of the different environmental conditions upon the toxicity of the chemical. It has further stimulated research upon the more fundamental problem of the physiological action of TCA in plants. A study of a few of the many aspects of TCA activity in crops and soils will be discussed. It has been reported that TCA will injure some crops in the year following spraying and this problem has been investigated further. A series of experiments were conducted to measure the relative toxicity of TCA under conditons where the applicstion of the chemical was delayed or was leached into the soil by water. Information has also been obtained about the behavior of TCA once it has been taken up by the plant.

Residual activity of TCA - Because of the early concern that TCA would remain in the soil for more than one growing season, we initiated experiments in 1950 to study this problem. Large areas of organic and silt loam soil were set aside for studying the residual activity of TCA in the soil. For example, 30 pounds of TCA per acre was applied to some plots in 1950. Other plots received 30 pounds in 1950 and 30 pounds in 1951. These plots were tested with snapbeans, one of the most sensitive plants we could find. In the same manner, other plots were sprayed with 15 and 5 pounds of TCA. The response of snapbeans grown in these areas in 1952 is shown in table 1.

Table 1.

Yield of Green Beans from Areas Treated with TCA in 1950 and 1951.

Total quantity of TCA applied to the soil.	Weight (lbs.) of green beans	
	Organic	Silt loam
60 pounds- (30 pounds applied in each year of 1950 and 1951)	29.5	64.0
30 pounds- (15 pounds applied in each year of 1950 and 1951)	32.1	79.6
Control (no spray)	28.9	60.8

Time of pre-emergence application-and effect of water application- From past experiments with other herbicides, it seems desireable to attempt to measure the effectiveness of the chemical when applied at several intervals following planting of the crop. The influence of rainfall appears to be an equally important consideration. Four experiments were conducted in two years upon silt loam soil where the plots were covered with plastic sheets to prevent rainfall from interfering with the treatments. The results were somewaht variable because of the uneven weed populations and our inability to control the amount of moisture in the soil at the time of planting.The trends of these data indicate that the control of weeds will be slightly improved if the spraying is delayed for 3 to 4 days after planting the beets. However the occurrence of rainfall and the amount of moisture in the soil at the time of planting will exert a greater influence upon the effectiveness of a spray treatment. In summary, it may be said that because of the amount of rainfall and hence the amount of available moisture in the soil at planting.time is unpredictable, no considerable advantage may be gained by making a special attempt to regulate the time of pre-emergence spraying.

Behavior of TCA - The behavior of TCA in the plants was studied by determining the concentration of the chemical in various plant tissues following absorption from the soil. The rate of accumulation of TCA in the leaves of young bean plants was studied. The amount of TCA in the various organs of the bean plant was compared with that found in comparable tissues in the pea plant. In all of these studies the plant tissues were homogenized and the concentration of TCA was determined upon a clear extract with the use of a colorimetric method initially described by Hummer.

The young bean plants showed a very rapid uptake of TCA for 6-8 days at which time the leaves began to die. The concentration found was approximately a milligram of TCA for each gram of fresh leaf tissue.

The tests reveal that certain organs of bean and pea plants showed the same ability to accumulate TCA. A very marked difference was found however, in the amount of TCA present in the terminal buds of the two plants. As may be seen in Table 2 the highest concentration of TCA in any of the organ of the bean plant is shown to be in the terminal buds. In striking contrast no TCA is to be found in the terminal buds of peas.

Table 2.

Distribution of TCA in Snapbeans and Peas (soil treatment)

Plant part	Micrograms of TCA per gram of fresh tissue	
	Beans	Peas
Terminal buds	1190	0
Leaves	418	540
Stems	22	0
Roots	66	96

An exploratory analysis of young beet plants showed no TCA in the growing point and only very low levels in the expanded leaves.

In other experiments older bean plants were treated by applying TCA to the soil in which they were growing just as they began to bloom. They were analyzed after three days. Very high concentrations of TCA were found in the flowers, very young ovaries, and in the young trifoliate leaves. There was no TCA in the unifoliate leaves and only small quantities in the other fully developed tissues.

In all of the previous references to trichloroacetic acid we have not meant to infer that the chemical found inside the plants is necessarily the trichloroacetic acid molecule as such. We have made no attempts to fractionate or isolate the active compound. It is entirely possible of course that we may be working with a breakdown product of TCA or a complex of TCA with some organic constituent of the cells. Similarily, the absence of measureable TCA in a tissue does not preclude the possibility that the chemical is entering the cells and is being tied up or metabolized.

We do not know at present, therefore, whether the tolerance to TCA is associated with an ability on the part of a plant to prevent absorption and translocation of the chemical to the young sensitive tissues, or whether the lack of injury may be due to an early metabolism of the compound or the formation of an inactive compound which we are not able to detect with our analytical procedure. It is clear, however, that the earliest and most severe symptoms of injury are associated with those centers where the chemical occurs in the greatest amounts.

CHEMICAL WEED CONTROL STUDIES WITH SUGAR BEETS

E.T. Andersen, University of Manitoba.

In 1948 the Plant Science Divison of the University of Manitoba, cooperating with Manitoba Sugar Company, began studies on chemical weed control possibilities for sugar beets. The Plans and chemicals as suggested by the sugar beet committee of the NCWCC were followed fairly closely. Since that time 32 different chemicals in different formulations, rates, times and methods of application, have been tested. Only a few have shown real promise.

Control of most common broad-leaved annual weeds has been most effectively accomplished with sprays of sodium chloride at rates of 200 lbs. per acre applied in 100 gal. of water. This treatment causes considerable puddling of the soil, requires much water, does not control grass weeds and the long term effect on the land has not been determined. With the use of 2,4-D in grain crops forming part of the sugar beet crop rotation, the broad leaved weed menace is wanting and salt is now rarely used.

Greatest satisfaction has been obtained with TCA applied either pre-or post emergently. This chemical has proved effective in controlling green foxtail Setaria viridis at rates of 7½ to 10 lbs. per acre. Rates up to 15 lbs. per acre have given fairly good control of several broad leaved species including Brassica arvense, Thlaspi arvense and Amaranthus retroflexus, Lamb's quarters have not been controlled by such treatments. Slight injury to beets has resulted at the higher rates when applied post-emergently.

In 1952 the emphasis on sugar beet weed control was placed mainly on 2 weeds: Green foxtail and Wild oats Avena fatua. These have become the predominant weeds in sugar beet fields (particularly in light soil regions), and the most difficult to control. Experiments were carried out using plots each of which consisted of a central row of wild oats, two rows of sugar beets on either side of the central row, and a row of green foxtail between each of these 2 rows of beets. All weeds excepting those seeded in the above rows were removed by hand. Chemicals which had previously shown promise as grass weedicides were included in the tests. A brief summary of results follows. TCA (sodium salt) at 10 and 15 lbs. per acre applied both pre-and post emergently effectively controlled green foxtail. At 5 lb./A fair control was obtained only when applied post-emergently. Wild oats was not noticeably affected by any of these treatments. The highest rate applied post emergently caused some temporary damage to the sugar beets. On the other hand IPC and CIPC effectively controlled wild oats when applied either pre- or post-emergently. Rates used were 4 and 8 lbs. post emergently and 4, 8 and 16 lbs./A pre-emergently. Neither of these controlled green foxtail.

Endothal (EC3740 (16% endothal)) applied pre-emergently at 8 lbs./A controlled green foxtail only; applied at 8, 12 and 16 lbs./A post emergently, in addition to control of green foxtail wild oats were stunted and reduced in stand. 4 lbs./A produced fair control of green foxtail only. Applied at 8 lbs./A and disced into the soil just prior to seeding, both weeds were effectively controlled. Sugar beets were not noticeably affected by any of the endothal treatments.

Several combinations of the above chemicals and these along with other chemicals were tried with interesting results in some instances. TCA at 5 lbs./A applied with endothal at 2 lbs./A was ineffective pre-emergently but gave practical control of green foxtail when applied post-emergently. Endothal at 4 lb./A with EH-5722 at 2 and 4 lbs./A post-emergently gave fair control of both weeds. Endothal with CIPA gave similar results when used at the same rates. Endothal at 4 lbs./A with IPC at 4 and 8 lbs./A effectively controlled both weeds. None of these combinations caused noticeable permanent injury to the beets.

Other chemicals included which produced no striking effects on the weeds were Dichloral urea EH2 (rates up to 5 lbs.), Xanthogen disulphide, (rates up to 30 lb./A), CMU (rates up to 2 lb./A), the two latter only applied pre-emergently; and N-1 naphthyl phthalamic acid (rates up to 6 lbs./A), which caused serious injury to the beets.

These rather clear cut results might have been caused, at least in part, by weather conditions. Immediately after the application of the post-emergent treatments followed a period when several heavy rains occurred which produced saturated soil conditions in the plots for several weeks. In previous seasons both IPC and CIPC have been relatively inert (as weedicides) when used on any type of weed or crop. For this reason the striking effectiveness in 1952, of this chemical, is attributed to moisture conditions. It is quite possible that effectiveness of some of the other chemicals may also have been influenced. The striking control of green foxtail with either endothal or TCA and control of wild oats with IPC would seem to offer hope of obtaining control over both with a combination - at least during wet seasons.

PRE- AND POST-EMERGENCE WEED CONTROL IN ONIONS.

E.K.Alban, Ohio State University.

Weed control in direct-seeded plantings of onions represents one of the most difficult problems faced by onion growers in Ohio. There is considerable evidence that one of the major factors contributing to the reduced acreage of this crop in Ohio, during the past twenty years, has been the lack of a satisfactory weed control program. Labor costs for "crawling", "wheelhoeing", or other cultivation practices during the past several years have ranged from $ 125.00 to $ 200.00 per acre.

While there were certain chemical weed control measures such as sulfuric acid, calcium cyanamide, and di-nitro compounds used prior to 1946, the greatest use and interest in weed control chemicals has taken place during the past six years. Since the 1946 season, the Ohio station has carried on rather extensive studies in an attempt to find a

satisfactory chemical or chemicals which would reduce the cost of weed control with the onion crop. While these studies have been conducted on upland soil (Brookston and Miami silt loam) as well as on much soil, the results presented in this paper will include primarily those obtained during the past four years at the Ohio Much Crop Experiment Farm at Celeryville, Ohio.

Procedure

Two varieties of onions were included in these studies, Brigham Yellow Globe and Sweet Spanish. Both varieties were included in the yield studies (1949, 1951, and 1952) but in the 1950 season, only Brigham Yellow Globe was included. In the pre-emergence studies, which included observations and data recorded only during the first four to six weeks after emergence of onions, both varieties were included.

Yield Studies: Direct-seeded plantings were made each year with a single row Planet Jr. seed drill during the April 25th to May 10th period (each planting and harvest dates listed under each Table). In the 1949, 1950, and 1951 seasons, four-row plots spaced thirteen inches between rows were used. In the 1952 season, three-row plots spaced sixteen inches between rows were used. Plot length in 1949, 1950, and 1952 seasons, was 25 feet with five replications for each treatment. In 1951, plot length was 50 feet with three replications for each treatment. Split block randomization was followed in plot layout for each of the four years. Cultivation with a wheel-hoe was carried out uniformly with all plots each season. Weed control studies were primarily concerned with the three to four inch strip on each side of the row.

Check or non-treated plots were "crawled" or hand-weeded as needed through the season. Pre-emergence treated plots were hand-weeded as needed, after effective period of treatment, through the season. Post-emergence treated plots were "crawled" or hand-weeded prior to treatment. All large weeds were removed from all plots prior to post-emergence applications.

All pre-emergence chemical weed control sprays were applied as an overall spray over the three or four row plots. These sprays were applied approximately twenty-four to thirty-six hours before emergence of the onions. Post-emergence sprays were applied as directed sprays at the base of onion plant and covered a strip three to four inches wide on each side of the row. In 1949 and 1950, these sprays were applied with a single-boom, knapsack type of sprayer. In 1951 and 1952, a special sprayer was designed with vine-lifters and six or eight nozzles so that a directed spray could be applied on a three-row or four-row plot.

The chemicals used, rate and total solution per acre, and time of application are listed in Tables 1,2,3, and 4. The rate and total solution per acre are presented as for complete coverage of total plot. In post-emergence sprays, rates were reduced to coincide with the actual area covered.

The major weed species encountered in these studies included, red-root or pigweed, Amaranthus spp., ragweed, Ambrosia artemisifolia L., galinsoga, Galinsoga parviflora, purslane, Portulaca oleracea, crabgrass, Digitaria spp., and foxtail, Setaria spp. During the first four to six weeks, Amaranthus spp. were of major importance, during the next three to six weeks Setaria spp. predominated, and during the latter part of the season through harvest, Portulaca oleracea was by the farm the most important weed species encountered.

Weed counts and evaluation based on commercial weed control were made at certain intervals during the season. Weed counts are not presented here since without listing species and describing general size and vigor, the information is apt to be misleading. Commercial weed control evaluation, as used in this presentation, was based on the relative values of '0' for very poor control through '5' for excellent control.

Pre-emergence studies: Over four-hundred separate pre-emergence applications of herbicides have been made on duplicated or additional replicated direct-seeded plantings of onions during the past six years. These tests have been made on the heavier upland soils as well as on much soils. While these pre-emergence applications have been made from time of planting through emergence of onions, the results presented in Table 5 include only those treatments which were applied within one or two days of emergence of onions. Data presented in Table 5 includes the average percent stand, as related to untreated checks, the average commercial weed control evaluation, and the number of tests included in obtaining these averages.

Results and Discussion

Yield Studies: In Table 1, 2, 3, and 4, the yields of onions are reported as calculated bushels per acre based on the average of all replications of any specific treatment. Analysis of variance of original plot yields were determined prior to projecting data to calculated bushels per acre and LSD from pounds to bushels.

Table 1.

The effect of certain pre- and post-emergence herbicide applications on the yield of onions and relative weed control. 1949.

No.	Treatment Chemical	lbs./acre	gals./acre	Time	Bushels per acre Brigham Yellow Globe	Sweet Spanish	Weed Control
1.	Check-weeded	-	-	-	379	510	5
2.	EXD emulsion (a)	5.0	50	Pre-(b)	215	340	4
3.	EXD emulsion & KOCN	5.0 & 8.0	50	Pre- & Post-(c)	114	140	3
4.	EXD emulsion & SPCP	5.0 & 8.0	50	Pre- & Post-	73	60	4
5.	PCP (Shell)	5.0	50	Pre-	243	399	4
6.	PCP (Shell) & KOCN	5.0 & 8.0	50	Pre- & Post-	112	133	3
7.	PCP (Shell) & SPCP	5.0 & 8.0	50	Pre- & Post-	78	94	4
8.	Stoddard Solvent & KOCN	- & 8.0	50	Pre- & Post-	220	176	3
9.	KOCN	4.0	50	Post-	209	192	1
10.	KOCN	8.0	50	Post-	190	73	2
11.	KOCN	4.0 & 8.0	50	Post-	180	144	3
12.	SPCP	4.0	50	Post-	13	10	5
13.	SPCP	8.0	50	Post-	6	6	5
14.	SPCP	4.0 & 8.0	50	Post-	0	0	5
				LSD 5%	59	89	
				LSD 1%	78	120	

Onions planted April 29th and harvested September 10, 1949
(a) EXD, abbrev. for ethyl xanthogen disulfide.
(b) Pre-, pre-emergence treatments applied May 7th.
(c) Post-, post-emergence treatments applied June 2nd and 24th, and July 15th and 30th. Where two rates are listed under post-emergence, the lower rate was used during the first two sprays and the higher rates for the last two sprays.

Table 2.

The effect of certain pre- and post-emergence herbicide applications on the yield and size of onions and relative weed control evaluation. 1950.

No.	Treatment Chemical	lbs./ acre	gals./ acre	Time (a)	Brigham Yellow Globe Bushels per acre	Ave. Bulb size lbs.	Weed control
1.	Check-weeded	-	-	-	834	0.147	5
2.	Stoddard Solvent	-	40	Pre-	846	0.136	5
3.	Stoddard Solvent	-	80	Pre-	847	0.148	5
4.	PCP (Dow)	12.0	50	Pre-	971	0.190	5
5.	PCP (Shell)	10.0	50	Pre-	598	0.218	5
6.	SPCP	4.0	80	Post-	564	0.133	4
7.	SPCP	6.0	80	Post-	446	0.118	4
8.	KOCN	12.0	80	Post-	651	0.129	2
9.	KOCN	20.0	80	Post-	620	0.122	3
10.	PETCA (b)	4.0	50	Post-	802	0.137	1
				LSD 5%	144		
				LSD 1%	206		

Onions planted May 4th and harvested September 9th, 1950.
(a) Pre-emergence treatments applied May 12th. Post-emergence treatments applied May 26, June 21, and July 18.
(b) PETCA, abbrev. for phenoxyethyl trichloroacetate.

Table 3.

The effect of certain pre-emergence, post-emergence and lay-by herbicide applications on the yield and relative weed control evaluation, 1951.

No.	Chemical	lbs./ acre	gals./ acre	Time (a)	Bushels per acre Brigham Yellow Globe	Sweet Spanish	Weed control
1.	Check-weeded	-	-	-	697	933	5
2.	KOCN	12.0	80	Pre- & Post-	438	438	2
3.	KOCN	20.0	80	Pre- & Post-	454	398	3
4.	SIPX (b)	8.0	80	Pre- & Post-	374	252	3
5.	SPCP	6.0	80	Post-	694	758	3
6.	SIPX	12.0	80	Post-	640	618	3
7.	STCP (c)	8.0	80	Post-	620	731	4
8.	CIPC	4.0	50	Post-	700	719	4
9.	EXD (Suspension)	10.0	50	Post-	629	654	3
10.	EXD (Emulsion)	10.0	50	Post-	740	842	4
				LSD 5%	139	178	
				LSD 1%	191	245	

Onions planted April 30th and harvested Sept. 10th, 1951.
(a) Pre-emergence treatments No. 2,3, & 4 were applied eleven days after planting. Post-emergence applications were made on these same three plots on June 7th, July 10th and 30th. Treatments No. 5,6,7,8,9, and 10 were applied only on July 30th, four days after the last cultivation.
(b) SIPX, abbrev. for sodium isopropyl xanthate.
(c) STCP, abbrev. for sodium trichlorophenate.

Table 4.

The effect of certain pre- and post-emergence herbicide applications on the yields of onions and relative weed control evaluation. 1952.

No.	Chemical	lbs./ acre	gals./ acre	Time (a)	Bushels per acre Brigham Yellow Globe	Sweet Spanish	Weed Control
1.	Check-weeded	-	-	-	502	916	5
2.	Stoddard Solvent	-	80	Pre-	491	937	5
3.	KOCN	12.0	80	Post-	392	807	3
4.	SIPX	12.0	80	Post-	414	719	3
5.	STCP	20.0	80	Post-	251	545	3
6.	SPCP	8.0	80	Post-	316	676	4
7.	CIPC	3.0	50	Post-	371	807	3
8.	CIPC	6.0	50	Post-	338	752	5
9.	EXD (Suspension)	10.0	50	Post-	328	621	3
10.	SPCP	16.0	80	Post-	294	643	4
11.	KOCN	20.0	80	Post-	338	632	4
12.	SIPX	20.0	80	Post-	350	632	4
				LSD 5%	68	122	
				LSD 1%	92	166	

Onions planted April 22nd and harvested Sept. 16th, 1952.
(a) Pre-emergence treatment No. 2 was made on April 29th, All post-emergence treatments No. 3 through 12 were made June 24th, July 14th and 30th.

Preliminary and concurrent studies had revealed that there were several herbicides which could be applied as delayed pre-emergence treatments on onions with little or no crop damage and that reasonably good commercial weed control could be obtained, Table 5. Therefore in the yield studies, an evaluation of the suggested post-emergence herbicides was considered primarily. Time, rate, and frequency of application of post-emergence sprays relative to commercial weed control and subsequent effect on yields of onions were the major aspects of the yield studies.

One of the most important results obtained during the four year period of study was the fact that in practically every instance where more than one post-emergence spray was applied to onions, there was a significant reduction in yield with both varieties of onions. These herbicide sprays included potassium cyanate (KOCN), sodium isopropyl xanthate (SIPX), sodium trichlorophenate (STCP), sodium pentachlorophenate (SPCP), ethyl xanthogen disulfide (EXD) emulsion or suspension, and isopropyl-N-(3-chlorophenyl) carbamate (CIPC). With the exception of the 3.0 pound rate of CIPC in 1952, Table 4, the application of two or more post-emergence sprays of these chemicals resulted in statistically significant reductions in onion yields. The post-emergence application of phenoxyethyl trichloroacetate (PETCA) at 4.0 pounds per acre did not reduce onion yields but was of practically no value as an herbicide, Table 2. Higher rates of this chemical resulted in severe damage to onions.

Single applications of SIPX, STCP, CIPC, and EXD suspension, as lay-by treatments, resulted in statistically significant reductions in yields of Sweet Spanish but not with Brigham Yellow Globe onions, Table 3. The EXD emulsion and SPCP lay-by treatments did not significantly reduce the yield with either variety in 1951 studies, Table 3.

With the exception of slight reduction in stand with the pre-emergence treatments of PCP and EXD emulsions, Tables 1 and 2, none of the other pre-emergence treatments such as KOCN and SIPX, Table 3, or Stoddard Solvent, Tables 1, 2 and 4, were of any

Table 5.

The effect of certain pre-emergence herbicide applications on the average stand, percent of check, of onions and the relative weed control, 1946-1952.

No.	Chemical	Rate per acre lbs.	Average stand percent of check	Weed Control	Number of Tests
1.	2,4-D, IP ester	0.5	90	5	4
	" plus rainfall	0.5	10	5	3
	", LV ester	0.25	86	5	2
	" plus rainfall	0.25	26	5	2
2.	SES	2.0	91	3	2
	"	3.0	85	4	2
	"	4.0	61	5	2
	" plus rainfall	3.0	82	5	2
3.	CIPC	3.0	81	3	3
	"	6.0	74	4	4
4.	CMU	0.5	55	4	2
	"	1.0	0	5	4
5.	PCP (Shell)	5.0	86	4	8
	"	10.0	76	5	9
6.	PCP (Dow)	8.0	89	4	7
		10.0	88	5	8
		12.0	76	5	10
7.	EXD (emulsion)	5.0	90	4	7
	"	10.0	81	5	9
8.	SPCP	4.0	89	3	3
	"	6.0	84	3	2
	"	8.0	72	4	4
	"	16.0	27	5	5
9.	KOCN	12.0	92	3	7
	"	20.0	91	4	9
10.	SIPX	8.0	90	4	6
	"	16.0	88	4	6
11.	Stoddard Solvent	50 gals.	95	5	8
		60 gals.	96	5	8
		80 gals.	95	5	10
		100 gals.	93	5	12

consequence in contributing to lower yields of onions where both pre-emergence and post-emergence treatments were applied. Stand counts and comparison of general size and vigor of onion seedlings, following pre-emergence treatments, did not differ markedly from hand-weeded check plots, with the exception of the previously mentioned EXD emulsion and PCP treatments. However within a few days after the first post-emergence sprays were applied to the previously pre-emergence treated plots, there was a slight to severe dwarfing effect on onion seedlings and a subsequent reduction in stand. Each succeeding post-emergence treatment resulted in a continued reduction in stand and increased damage to onions. As used in these studies, the approximate order of treatments relative to toxic effects on onions was, SPCP, SIPX, KOCN, STCP, CIPC and EXD suspensions. The value of these treatments relative to weed control followed approximately the same order with differences primarily associated with concentration used.

Pre-emergence treatments with Stoddard Solvent, Tables 2 and 4, were satisfactory, as related to weed control and minimum damage to onions. These treatments eliminated the need for the first "crawling" of onions and greatly facilitated the first cultivation. The lack of weeds and the upright growth of onions, in these plots as compared with the "crawled" check plots, allowed for closer cultivation with the wheel-hoe. The results with pre-emergence treatments of pentachlorophenol (PCP), and EXD emulsion, not complicated with post-emergence treatments, were generally less favorable than the Stoddard Solvent pre-emergence treatments. There was only one instance where the yield of onions was not significantly reduced with these treatments, Treatment No. 4, Table 2.

The control of purslane, which was one of the most important weed problems on the muck soils during the last eight weeks of the season, was accomplished with all concentrations of SPCP, SIPX, and CIPC. The results with KOCN, STCP, and EXD emulsions and suspensions, as post-emergence treatments, were generally more variable but still provided a fair to good control of this weed.

The CIPC, KOCN, EXD emulsion, SPCP, STCP, and EXD suspension post-emergence sprays provided fair to excellent control of crabgrass and foxtail, with CIPC providing the best control and the EXD suspension providing only fair control. Post-emergence sprays of SIPX were entirely inadequate as related to these two weed species. Addition of wetting agents to KOCN, SIPX, and STCP increased their effectiveness with these two grass species but resulted in increased damage to the onions.

Pre-emergence treatments of Stoddard Solvent, PCP, EXD emulsions, and KOCN and SIPX with wetting agents, provided excellent control of pigweed, annual grasses, and the few miscellaneous broadleaf weeds, which had emerged prior to the time of spraying. The only exception was with ragweed, where the Stoddard Solvent was generally not too effective.

Pre-emergence Studies. These studies were conducted with direct-seeded plantings of onions on muck soil and on Brookston and Miami silt loam soils during the 1946 through the 1952 seasons. In most instances, supplemental irrigation was available and was used in obtaining the results reported in Table 5. During the first two years of the study, it was found that a smooth, firm seed-bed, with ample soil moisture was essential to the effective use of pre-emergence herbicides. The sensitivity of the onion seedling to leaching damage with many of the herbicides used, as well as reduced control of weeds, indicated the value of delaying pre-emergence herbicide applications to the twelve to thirty-six hour period preceeding the emergence of the onions. While it is generally agreed among research workers in the field of herbicides that muck soils will take and usually require higher rates of such chemicals as 2,4-D, SES, PCP, SPCP, and other contact residual, systemic, or growth regulating types, our results indicate that soil moisture will more or less tend to level off these differences between muck soil and the heavier mineral soils. Therefore, in Table 5, the percent stands are presented as average values of both muck and upland soil studies, since under optimum moisture conditions, these differences were usually less than ten percent higher on the muck soils.

Of the pre-emergence herbicides studied, Stoddard Solvent was by far the most effective material with onions. During the first two years of these studies, results with Stoddard Solvent were somewhat variable. In all of the later studies, where Stoddard Solvent of a guaranteed analysis, fifteen to eighteen percent was used, results have been entirely satisfactory both in relation to effective weed control and minimum crop damage.

Results with KOCN and SIPX plus wetting agent were almost as effective as with Stoddard Solvent. But where lower temperatures and somewhat dryer soil conditions were encountered these chemicals were less effective than Stoddard Solvent.

With materials such as PCP, SPCP, CMU, EXD emulsion, 2,4-D and other contact residual or systemic herbicides, as the concentration of the chemical was increased for most effective herbicide performance, the damage to onion was also increased.

Of the newer suggested herbicides, CIPC and SES seem to warrant further study as indicated by the average percent stand in pre-emergence studies listed in Table 5. While the margin of safety with

these herbicides is rather narrow, as shown by the reduced stands with the higher rates of application, there were minimum visible symptoms of herbicide damage to onions as compared with most of the other contact residual or systemic herbicides used in pre-emergence. There was considerable evidence that leaching was less of a hazard with these two herbicides on the muck and silt loam soils included in these studies.

Conclusions

Under Ohio conditions, with onions grown on muck soils, Stoddard Solvent, KOCN and SIPX plus wetting agent, were the safest and most satisfactory pre-emergence treatments used for chemical control of weeds. The effective period of weed control with these chemicals was approximately three weeks. Increased periods of effective weed control were obtained with PCP, SPCP, CMU, 2,4-D, SES, CIPC and EXD emulsion, as pre-emergence treatments, but generally resulted also in excessive reduction in onion stand.

The use of KOCN, SPCP, STCP, SIPX, CIPC, and EXD, as directed basal post-emergence sprays with Brigham Yellow Globe and Sweet Spanish onions, under Ohio conditions, involves considerable hazard to the crop. In every instance, except one, when these chemicals were applied two or more times to onions there was a statistically significant reduction in yield as compared with the hand-weeded onions. There was some evidence that a single application, as a lay-by treatment, of the above chemicals might be used with Brigham Yellow Globe. However with Sweet Spanish onions, all of the above chemicals, applied as a single lay-by treatment, resulted in reduction of yield.

WAYS AND MEANS OF GETTING INFORMATION ON WEEDS AND THEIR CONTROL TO THE FARMER.

A.f. Shaw, Saskatchewan Department of Agriculture.

The general definition of a weed implies that it is a problem - weeds are plants growing where they are not wanted.The special characteristics of each weed assures its status in the weed class and its individuality as a specific problem.

For those of us at this conference, we have individually established weeds as a problem, and each weed as a specific problem. Collectively we can identify them all. We know their special characteristics, and vulnerable spots. We recognize the losses due to weeds as a sizeable economic loss to the farmer. At the close of the conference we will be up to date on the latest in weeds and their control. Our main concern will then be getting this information over to the farmer.

Some farmers and farming communities have eradicated and are controlling weeds to their and our satisfaction. However, there is that large section of farmers who are not effectively controlling weeds. This is the chief reason why we are here today. Ways and means of getting information on weeds and their control across to farmers is our problem at the moment.

Let us first consider the nature of our weed problem:

- Weeds are an old subject, one which most farmers are not easily stirred up about. They have lived and farmed with weeds all their lives.
- Weeds for the most part establish themselves on the farm without the knowledge of the farmer.
- Weeds usually become established slowly and the farmers losses are increased gradually over a period of years.
- Weeds often wax and wane in their significance due to environment and other natural causes.
- Weeds are almost always a community problem as well as an individual one.
- Each weed if a problem is a specific problem and should be recognized and treated as such.
- For the most part each weed is a real problem in a limited area due to soils, climate, farming methods and other factors.

The above considerations indicate that extension work on weeds and their control is one which will require attention on a community as well as on an individual level.

To achieve the greatest success in weed control our extension approach should be governed by the type of information to be put across, to whom it is directed, as well as how important it is that farmers do something about it.

THREE EFFECTIVE EXTENSION APPROACHES TO THE WEED PROBLEM ARE DISCUSSED BELOW.

A MASS APPROACH to the weed problem is aimed at directing as much information as possible at the farmer with the hope that large numbers will pick it up, sort it out, and put it into practice.

This approach is directed to supply information to large numbers of farmers through press, radio, films, posters, exhibits and formal speakers at meetings. It is used to give out information to smaller meetings through media such as 2 x 2 slides, charts and specimen green or pressed weeds and others. Methods such as tours, projects and demonstrations are employed to inform the farmer on weeds.

The main emphasis, through this approach, is by design, a one way flow of information from an authority to the farmer who is expected to make use of it, This mass approach is based on the assumption that, given sufficient information farmers will solve their own weed problems. However, some farmers are not receiving this information in a useable form, and in other instances the neighbour is not aware of his share in solving a community weed problem.

Mass approach methods and techniques are effective mainly for new and startling information. They are useful and effective in passing information on to farmers who have identified the weed concerned, and where the weed has been established as a problem. Usually they are effective as a means in supplying information to farmers who have a keen interest in good farming, and where farming is carried on as a business.

To the poorer than average farmer mass approach methods on weeds and their control are usually like the long speech, or like the big wheel - the longer the spoke the bigger the tire.

AN INDIVIDUAL APPROACH to the weed problem involves methods whereby the farmer is contacted directly. Here the extension worker is inviting an exchange of ideas between himself and the farmer.

A direct means under this approach is through personal visits or by telephone. The personal visit with the farmer on his farm speeds up an exchange of ideas. It is usually the most productive method, and the surest approach to the farmers individual weed problem. This method is costly in time and money, but most satisfying to the farmer and the extension worker

The indirect means under this approach involves the use of letters, circulars, pamphlets and associated methods. Pamphlets are only effective if they are sufficiently attractive and interesting to attract the farm reader. The most promising bulletin of this type which I recall at the moment is "Iowa Farm Science" put out monthly from Ames, Iowa. This pamphlet type publication is well illustrated, written in talk fashion with sentences averaging around 10 to 15 words, and short paragraphs.

Farmers will read pamphlets written in the news form where the central idea comes first. Farmers will read them if written in the story form where the central idea comes last, if they are of the human interest type. Few farmers will read articles of the usual technical paper type with unfamiliar terminology set out progressively in point form and conclusions last.

Through this approach almost any individual weed problem could be solved if sufficient extension workers were available.

A PROBLEM APPROACH to our weed problem is usually employed where it is intended to limit the number of farmers taking part. It caters to special interest groups and special problem groups. This approach builds a setting for an exchange of ideas, group discussion and resulting group action.

A group problem solving approach when used by one or two extension workers on a group of farmers usually begins by methods or techniques for supplying information on weeds and their control as outlined under the mass approach. such as films, 2 x 2 slides, speakers, etc. When the information has been presented to a group, of usually under one hundred farmers, this group immediately assemble in small discussion or forum groups to establish the problem, work out solutions, and a plan of action. These discussion or forum groups of less than 10 farmers are more successful than a larger number at reaching decisions.

This approach when used in a group with a number of extension workers present may provide the opportunity to dispense with the preliminary mass information methods and techniques, and the meeting may assemble into forum groups with a technical person in each small group to supply technical information as required.

A small group problem solving approach makes provision for each farmer in attendance to take an active part in establishing the problems. He has an active part in working out solutions and plans, which he as a member of the community will be assisting to carry out.

These methods are effective in getting at specific problems and community problems. Here technical and practical ideas on weeds and their control are exchanged quickly and freely. Through this approach the farmer is actively involved in making plans which encourages his determination to have them carried out.

Methods used in this approach also has considerable influence on the farmer who does not attend such meetings, since in groups, farmers are reasonably successful in regulating the conduct of their neighbours.

SUMMARY

In putting information on weeds and their control across to the farmer, it is usually important to keep the following in mind.

Each weed is a specific problem to a particular group of farmers at a particular time. The farmer must be aware of the problem and its implications, and have a desire to do something about it.

The extension approach to the weed problem will have a great bearing on the success we might expect to achieve.

A mass approach is most satisfactory for supplying new and startling information to farmers where a one way flow of information on weeds is desirable, and to farmers who are interested and aware of the implications involved.

An individual approach is most useful where an exchange of ideas will lead to the solution of a weed problem on an individual farm. Here the solution may be worked into other practices necessary on this farm.

A group problem solving approach is most effective for solving a specific and community weed problem where the farmers involved are not all on the same level of awareness of the problem and its possible solutions.

OUR COUNTY WEED CONTROL PROGRAM, ORGANIZATION AND ACCOMPLISHMENTS.

A.B. Hagan, Dayton, Minnesota.

Organized weed control in Murray County, Minnesota began in 1931. At that time C.H. Schrader, who was serving the county as County Agent, organized the county under the Redwood Plan of weed control. This plan later became known as the Minnesota Plan of weed control and was widely adopted.

Early work under the plan was educational in nature. Actual control of weeds lagged due to cumbersome and expensive methods of control and to the lack of adequate laws to enforce a well rounded control program.

Later new teeth were put into the weed law by the Minnesota Legislators. This new development gave local authorities wider powers, provided greater penalties for failure to comply and made money available for the establishing of State weed projects and the employment of part time County weed supervisors.

Under the Minnesota Plan, farmers of the county were well acquainted with the weed problem of the county and the need for control, when new chemicals made their appearance in 1946.

With the advantage of a sound county organization and a sensible weed law and also the strong determination to do something about weeds, new methods were rapidly adopted. With the demand for more and more aid and information from the County Agent by farmers, it became necessary to employ a full time county Weed and seed supervisor in 1946.

At the present, 90% of Murray County farms are equipped with weed sprayers. In 1952, 161,000 acres of crops were treated with chemicals to control weeds, and farmers are anxiously waiting new and better chemicals which will further aid them in their control program.

APPLICATION OF CANADIAN WEED CONTROL LEGISLATION

G.R. Sterling, Alberta Department of Agriculture.

Probably all of the legislation pertaining to weeds enacted in Canada, or for that matter in any

country, was enacted to prevent the spreading of noxious weeds. Almost all of the weeds in Western Canada which are troublesome and a problem to the farmer today were introduced at one time or another from other parts of the world. Many of these plants are not weeds in their natural habitat but under the conditons of Western Canada they present a weed problem. As an example: Buckwheat is grown as a commercial crop in Eastern Canada and Tartary Buckwheat is not classed as a serious weed. But in Western Canada no seeds of Tartary Buckwheat (Fagopyrum tartaricum L) are allowed in any seeds of commerce. (See Table 1).

In 1905 the Canadian Government realized that seeds of commerce used on Canadian soils must be free of weed seeds. With this in mind, the Canada Seeds Act was first passed in 1905 and at present is known as the Seeds Act, 1937. This Act is nation wide and covers all kinds of seeds used by farmers, gardeners, horticulturists, etc. It is administered by the Plant Products Division of the Dominion Department of Agriculture. This Division has eight districts throughout Canada: one in New Brunswick, one in Quebec, two in Ontario and one each in Manitoba, Saskatchewan, Alberta and British Columbia. There are sufficient sub-offices under the District Supervisor to handle the area which he is responsible for.

The Seed Act, 1937 calls for different grades of seed. Generally they can be listed as Registered No. 1, 2 and 3 Seed: Certified No. 1 and 2, and Commercial Seed No. 1, 2 and 3. This Act contains detailed tables giving the maximum numbers of weed seeds allowed for the particular seed grade. I do not propose to give all of the numbers of weed allowed but as an example Table 1 gives the numbers allowed in seed wheat. Seed can only be Registered or Certified if it is grown from registered or certified stocks and field inspected during the growing season. The grower must produce the field inspection certificate and also have the seed graded as to weed seeds or other impurities before he can tag it as Registered or Certified. Commercial seed must be within the limits as to weed seeds and impurities but does not have to be grown from Registered or Certified seed stock.

All of the weed seeds are classified in the Act according to noxiousness. Classification is based on two principles: one, the difficulty of controlling the weeds in the field and two, the effort required to remove the weed seed from the particular seed in question.

This Act has done much to prevent the spreading of weed seeds in Western Canada. It does not, however, stop the farm to farm seed transaction which is often responsible for new weed infestations; nor does it prevent farmers from seeding weed infested seed. I am told that the Seeds Act in England makes it illegal for any person to knowingly sow seed containing more than the prescribed percentage of injurious weeds. This stipulation has not been put into the Canada Seeds Act because the authorities administering the Act feel that it would be too difficult to enforce at the present time.

Each of the four Western provinces have a Noxious Weeds Act. All of which are designed to prevent weeds propagating by seed or other means. Each provincial Act controls the movement of weed seed screenings. All of the four provinces attempt to control as many weeds as possible by using extension methods. However, because this method will not work satisfactorily on 100% of our farms it is necessary to have legislation to bring those farmers into line who will not accept recommended weed control practices

I do not propose to cover in detail all of the four Western Canada Noxious Weed Acts but because this meeting is being held in Manitoba I thought it appropriate to deal at some length with the Manitoba Act and then compare the other Acts with it.

Manitoba

The responsibility of weed control in Manitoba rests with the Municipality. They are responsible for the appointment of a Weed Inspector or Inspectors and if they fail to do so the Minister of Agriculture may appoint Weed Inspectors for an area, direct their work, pay them and recover such expenditures from the municipality concerned. The inspector can order weeds destroyed by a certain time. He can personally, or through an agent, destroy the weeds if the farmer does not carry out the order within the time limit. The cost of destroying the weeds can be charged against the land, which amount can be collected with the same priority as taxes.

The weed inspector may prohibit the seeding of any weed seeds, may enforce the seeding down of any earth works to grass, and can prohibit the sale of hay and feed products if they contain weed seeds. He can cut and destroy three acres of weeds and crop: larger amounts to be approved by the Reeve and Councillors.

Where the inspector finds land badly infested with weeds he may serve notice to the owner to the effect that the land can not be rented except under the following conditions: (1) a copy of the said notice has been given to the renter and, (2) the renter agrees in writing to assume all the responsibility for the weeds.Changing ownership of the land does not in any way affect this notice.

Under the Manitoba Act, land infested with Class one weeds may be declared by the Municipal Council to be a weed infested area. Class one weeds under this Act are Leafy Spurge, Field Bindweed, Hoary Cress and Russian Knapweed. In such areas the municipality may enter into an agreement with the owner, renter or, anyone else registered as mortgagee, etc., outlining the necessary steps to control said weeds. If this agreement is not carried out the Municipal council may by by-law enter on the land or authorize his agents to enter and reclaim the land from the weed infestations by any means the council deem advisable. The owner is prohibited from using the land. However, while the by-law is in force the land may be rented to a reliable farmer. Such an agreement can not control the land for more than 5 years unless renewed at each 5 year period. Any revenue derived from crops growing on the land is applied first to any expenditure made by the municipal council, second to taxes on the land and lastly, the excess is given to the rightful owner of the land.

This may seem like drastic action but I understand that those parcels of land taken over under this part of the Manitoba Act have been restored and brought back to productivity. This, of course, proves again a well known fact that land will respond to good treatment as well as poor treatment.

Saskatchewan.

In general the Saskatchewan Act resembles the Manitoba Act in that it is the responsibility of the municipality to appoint Weed Inspectors and generally enforce the Noxious Weeds Act. Here again, the Minister of Agriculture can appoint Weed Inspectors, outline his duties, etc., if the municipality fails to do so. The Weed Inspector may make an agreement with the owner of weed infested lands setting out the methods of destruction who shall pay for the cost of such work and all other matters pertaining to the control or the eradication of the weeds. If such agreement is not carried out by the occupant or owner, the Inspector may take steps to carry out the agreement and the cost involved can be recovered in the same manner as rates and taxes. The Inspector may carry out such agreements provided he does not have to spend more than $200.00 ($300.00 in the case of

sow thistle) per quarter section per year.

If the agreement is made for such weeds as Leafy Spurge, Russian Knapweed, Toad Flax and Hoary Cress and if it is not carried out by the owner or occupant of the land, the council may by by-law authoritize their Inspector or agent to enter on the land: to sow and harvest crops: to keep animals as needed, and prohibit the owner or occupant from using the land. The Reeve and Secretary of the municipality may lease part or all of the land for pasture purposes. All monies received can be applied to any municipal expense incurred: secondly, to taxes and the rest goes to the rightful owner. No agreement shall be longer than 5 years.

The Act provides that the owners or occupants may appeal to the Minister of Agriculture from such by-laws. The Minister may dismiss the appeal or order that the by-law shall not effect the land or any portion thereof. His decision in this matter is final.

Municipalities may make agreements with other municipalities to carry out control measures which require large machines, etc.

British Columbia

The Noxious Weed Act of British Columbia is similar to those of Saskatchewan and Manitoba as far as the responsibility of weed control is concerned: that is, it lies with the municipality. There are, however, two main differences: (1) Control regarding the sale of weed seed screenings is probably the most rigid of the four Western provinces. Perhaps this is due to the fact that grain is cleaned at the terminal elevators in Vancouver. (2) The act does not provide or allow the municipality to make agreements or take control of weed infested land. It does, however, provide for a weed control committee to be constituted in a weed control area. The Minister will set up such an area upon receipt of a petition of 60% of the people in the area.

The purpose and duty of this committee is to ascertain prevalence and distribution of weeds, to adopt such education measures as they deem necessary, to bring to the notice of inspectors weed conditions within the area and how they may be corrected.

Alberta

Alberta has two acts pertaining to weed control: the Noxious Weeds Act and the Agricultural Service Board Act. The Agricultural Service Board Act is wider in scope and includes other agricultural problems of mutual concern to the Provincial Government and the Municipalities.

In principle the Noxious Weeds Act of Alberta resembles very closely those of Manitoba and Saskatchewan. Alberta Weed Inspectors have practically the same power as Manitoba and Saskatchewan Inspectors with the exception that they can not take possession of land under the Noxious Weeds Act as can be done in Manitoba and Saskatchewan, under their respective Weed Acts. The machinery necessary to take possession of weed infested land in Alberta is contained in the Agricultural Service Board Act.

Under the Agricultural Service Board Act a Municipality may constitute an Agricultural Service Board, It is made up of two Municipal Councillors, two farmer ratepayers, residents in the Municipality and a Government representative. The Government member in every case is the local District Agriculturist serving the Municipality.

This Board acts in an advisory capacity to the Municipal Council and to the Alberta Department of Agriculture. The recommendations made by the Board to the Council are usually carried out by the latter body. Those Municipalities with Service Boards hire full-time Field Supervisors, who work on agricultural problems within the Municipality. The Boards were first inaugurated for weed control measures but in later years have worked on other problems such as crop diseases, pest control, livestock production, etc. Their main function, however, is still weed control.

Under the Service Board Act the weed menace may be handled in one of three ways.

(1) the problem can be handled if the Field Supervisor can persuade the farmer to adopt approved farming methods.

(2) if persuasion fails the Field Supervisor may be able to get the farmer to sign a supervision agreement. Such an agreement covers the following: (a) the farming practices to be followed, The agreement usually includes the cropping sequence on each field of the farm for the duration of the agreement. (b) It states whether the owner or occupant shall pay for the operating costs or whether the Municipality has to advance money to cover them. (c) If the Municipality advances the expenses, the agreement stipulates the terms of repayment. If the owner or occupant fails to repay any money as per the agreement he has made, the Council may by by-law declare that the amount owing shall be added to the taxes on the land and can be recovered under the Tax Recovery Act.

(3) the land may be taken under reclamation if neither No. 1 or No. 2 as outlined previously do not work to the satisfaction of the Service Board or Council.

Under reclamation the possession of the said land can be vested temporarily in the Municipal Council by by-law. The Municipal Council or their agent, who is usually the Field Supervisor is responsible to see that the land is properly farmed. He may farm the land by hiring the work done or the Municipal Council may rent it to a reliable tenant. Such rental agreements include the cropping plan of the farm and the operations that are to be carried on each year. Any monies derived from such an agreement are used to pay any indebtedness to the Municipality, taxes on the land and lastly any excess is returned to the rightful owner. The Municipal Council can rescind the by-law when the Service Board recommends that the land has been reclaimed and the weed menace controlled. To date all land taken under this section of the Service Board Act has not only paid off financially but has been cleaned up as well.

American Legislation

Perhaps a very brief comparison of Canadian and American legislation with regard to weed control would be in order. Generally speaking American Weed Acts appear to be much the same as those of our Western Provinces with the exception that most of the States attending this Conference do not have provisions in their Act to temporarily take possession of land and to farm it according to approved methods. One or two of the States attending here have such provisions, but generally it is not the case.

Secondly the Seed Laws in the American States are entirely different to those in Canada. Canada has one body controlling seed production, etc., for the whole Dominion. As near as I can determine each State represented here has its own adequate seed laws.They, of course, recognize the Seed Laws, certification, etc. of other States and Canada but do not appear to have the same uniformity as there is in Canada where one body enforces the Seed Act.

Table 1.

Maximum number of seeds per pound except where otherwise stated.

Grade Name	Noxious Weed Seeds: Primary	Noxious Weed Seeds: Primary plus Secondary	Total Weed Seeds	Seeds of other crops or species	Other Distinguisable varieties	Minimum Percentage Germination
Registered #1	0	0	3	0.5	1	85
Registered #2	0	1 per bu.	10	1	2	75
Registered #3	0	1 per peck	10	2	2	65
Certified #1	0	1 per peck	10	1	5	85
Certified #2	0	2 per peck	15	2	10	75
COMMERCIAL SEED						
No. 1 Seed	0	1	25	10	20	85
No. 2 Seed	1	3	50	25	30	75
No. 3 Seed	3	15	100	50	60	65

NOTE: (1). Seed graded or sold under this table in Manitoba, Saskatchewan, Alberta and British Columbia, shall be free from Tartarian Buckwheat (Fagopyrum tartaricum L.)

(2). Ergot (Claviceps purpurea) shall not be present in excess of 2 per peck in grade REgistered No. or 1 per pound in grades Registered No.'s 2 and 3.

COORDINATION OF THE WORK BETWEEN REGULATORY PEOPLE OF THE STATES AND PROVINCES OF CANADA

Crawford Winton, Oklahoma State Department of Agriculture

No doubt, many of you, in the eight previous meetings have heard the pros and cons of similiar topics with suggestions made by the speakers for a more coordinated effort in our Regulatory work. Although this is a topic on which we could spend considerable time in discussing, I am going to limit my remarks to a few points which I feel are extremely pertinent to any control or Regulatory program.

I should like to broaden this topic a little Mr. Chairman, by adding the word cooperation to the title. This would make it read"Cooperation and Coordination of the Work between Regulatory People of the States and Provinces of Canada". I believe this rephrasing applicable since any time of enforcement whether it be in the field of Weed, Seed, Feed or Fertilizer control is dependent to a great extent on the cooperation one gives and receives from neighboring states. In fact, this cooperation is a must for uniform control.

Now first consider for just a few minutes, a way which we may coordinate our efforts and work, through uniform administrative procedures. We all realize that this point is probably as significant as a uniform "Weed Infested Materials Act", or a "Weed Control Law". May I add here, that in my opinion the uniform "Weed Infested Materials Act" as modeled, planned and recommended by this group is certainly a step forward towards more uniform legislation between States and a better overall Regulatory program. I'll have more to say about this a little later. We all realize that obtaining uniform "Administrative procedures" is a large order, since our laws are so variable between States. However, much can be accomplished, with a little more effort exerted on the parts of all concerned.

I had an opportunity in 1950 to serve on the Administrative Committee of the Association of Southern Seed Control Officials. During my tenure with this Committee, we circulated a rather lengthy questionnaire concerning Administrative problems, as well as other questions on Seed Control, to the various states in our organization. This was done to try to bring about a more unified effort, with "cooperation between States" as its ultimate goal. Some of the questions, it appears to me, would be very applicable to this subject to help stress the point that I'm attempting to make, so let's look at a few of them. First question was something like this, "How many times in the past year have you given information about possible violations moving to neighboring states to officials in those States?" Then the next question "How many times in the past year have you received confidential information from neighboring officials regarding violations? and then, do you feel that an exchange of this confidential information is helpful?"

The answers to these questions from the various States left no doubt that much needed to be done towards the encouragement of this exchange of information. In answer to the first two questions, I believe only two of those that answered had received or given confidential information to neighboring states. All States answering the third question, were of the opinion that this exchange would certainly be beneficial to them. Now how would those of you who are present answer these questions? If you are from our neighboring State of Kansas, my hat is off to you for the way in which you have helped us, in our efforts of "Weed Control". They have, in the past year, on numerous occasions, wired us of movements of "Bindweed infested oats" moving either through, or from their State into Oklahoma. In many cases they have given us the destinations of these shipments and we were able to check on them at these points. This information has been invaluable to us. Again may I point out, many of us are not as fortunate as others, in that we do not have the facilities, personnel, or funds to carry on an extensive Weed Control Program, but even though some of our laws are inadequate, our Program could be done more efficiently with this exchange of information between States.

Further into the idea of uniform Administrative Procedures is the need for uniformity between States in enforcement procedures and dispositon of these violations. For example, let's think for a minute about a carload of "Bindweed infested oats" that your inspector has found in his territory. What instructions can you give him concerning this shipment? Should he "Stop Sale" or "Tie Up" the oats? If the oats have been unloaded and in the possession of a dealer can he grind

then enough to destroy the viability of the bindweed, and then offer same for sale? Another angle would be to hold the truck until the oats had been cleaned, sampled and passed on as "Bindweed Free?" The point is this, it isn't too difficult to find the violation but what do we do after we find it? These questions may seem elementary to some, but I'm sure we would really be surprised at the various answers we would receive if we took the time to ask each present. Another example which we faced this year was in imported truckloads of hay entering our drought sticken areas. I'm positive much of it contained vegetative parts of bindweed but what could we do under these circumstances? I don't know the answer to these uniform enforcement procedures between States and Provinces, but I certainly feel that getting together in meetings such as this, and openly discussing these matters, will make for closer cooperation and a better understanding between officials.

I mentioned awhile ago that the "Uniform Infested Materials Act" as recommended by this group as a guide for States, for future legislation, was surely a step towards more uniformity from a Regulatory standpoint. However, these Acts aren't nearly as easy to pass through legislature as one might think. May I tell you what happened to us in Oklahoma? Mr. Chairman, I believe we were the first State to attempt to get this "Uniform Act" passed and you may correct me if that isn't right. This proposal came before the Legislative Committee for consideration and was seemingly doing alright until the definition of "Noxious Weeds" came about. In defining "Noxious Weeds" it was so stated that "Noxious Weeds" would be Bindweed and those weeds to be designated by the State Board of Agriculture after due "Public notice or hearing." Immediately this was questioned and it seemed very possible that the entire "bill" would be thrown out, however, after much discussion the definition was rewritten to mean just bindweed and we were lucky to salvage even this. Thus our "Weed Infested Materials Act" covered "bindweed" only. Those of you who are contemplating trying to pass legislation such as this, don't be discouraged by this incident because, in reality I think we have definitely made a step forward. Eventually I feel much better legislation can be passed. You all recall the old adage that, "You have to crawl before you can walk".

There are many other points that we could discuss in attempting to coordinate our Regulatory work. Such questions as "Do you or should we apply tolerances, similarly applied by seed analysts, to weed seeds in our Regulatory Work?" or "Do you have regular training periods of instructions for your Inspectors?" and "What do you consider as a weed seed" or "Viable weed seed?"

These are just a few in a seemingly unlimited field of questions for us to consider. I appreciate very much this opportunity of talking to you and would like to hear your suggestions on this subject.

WEED CONTROL ON RAILROAD RIGHT-OF-WAY

S.J. Oberhauser, Minneapolis, Minn.

I am glad of this opportunity to discuss with members of the North Central Weed Control Conference, the railroad's program in controlling and eradicating weeds on our right-of-way.

We have long been conscious of the need to control noxious weeds on our property. Failure to do so invites trouble, not only from land-owners adjacent to the railroads, but also from the regulatory section of our state government, which by law must enforce the regulations specified therein.

However, the railroads have generally recognized their responsibility in this matter. They know that their prosperity coincides closely with the prosperity of the territory they serve. If the farmer isn't prosperous, then the railroads serving the area will soon feel the pressure of lower incomes. What has this to do with weeds?

Weeds reduce crop yields, and per-acre crop yields have a direct effect on our income. Therefore, it is to our advantage to follow any recommended procedure which will prevent the spread of noxious weeds to land along our right-of-way.

Our regulatory bodies, namely our Weed Commissioners in the various states, have been most cooperative with the railroads in their effort to affect good weed control measures. The Weed Commissioners or farmers whose property is threatened with infestation of weeds from railroad property, have in the past notified the local railroad agent as to the exact location and scope of such noxious weeds. The necessary measures are then taken up by the railroads to eliminate the infestation on their property.

By the same token, we assume the propriety of requesting that land-owners adjacent to the railroads accept the same responsibility of keeping their fields free of noxious weeds; otherwise, the effectiveness of our efforts is minimized, since weed seeds can and do travel in all directions, thereby reinfesting areas where control measures are followed.

The Milwaukee Road, comprising nearly 11,000 miles of line in twelve states, has many and varied problems associated with control of weeds. Our costs on this single item are tremendous. In 1951 they amounted to more than $318,000.00, of which amount $266,000.00 was for material only.

For the road bed section proper, which must be kept free of vegetation for safe operation of trains, our weed and grass killer has been a formulation of 10% creosote and 90% high flash point diesel fuel. Throughout the years it has proved successful; however, during the last two years, new and improved chemicals have been tried on an experimental basis for use in certain selected areas in our territory. These no doubt will receive greater attention in the years ahead for the purpose of making the formulation effective on a greater variety of weeds and making the control more lasting.

For control of noxious weeds, such as Leafy spurge, Canada thistle, field bind-weed, perennial sowthistle, hoary cress, etc., we have used various formulations of 2,4-D with varying results.

During 1952, the amine formulations of 2,4-D appeared more effective than the other formulations at certain locations under observation, although they did not act as fast as the esters. This may have been due to the unusual weather, local soil conditions and amount of root growth of the weeds. It is planned to continue these experiments for a period long enough to form a definite conclusion.

Our Engineering Department, under whose jurisdiction weed control is handled, likewise report some good results from the use of a number of new herbicides that have recently been placed on the market. From the viewpoint of the railroad, it is difficult to properly evaluate these new chemicals at the present time. Cost factors have not been determined. There are likewise problems associated with the handling of these new herbicides which must be solved. Our Engineering Department is cooperating with several chemical companies in connection with the development and use of new herbicides.

For railroad right-of-way, we have found the use of knapsack sprayers the most desireble for the reason that noxious weeds are usually found in small patches, which are inacessible to the larger power sprayers. In addition, a much lower pressure is used which minimizes drift compared to the dangers of high pressure equipment, resulting in broken hoses, etc. We feel, therefore, that our section men can use these sprayers without any particular hazard to themselves or adjoining crops.

Where there are large patches of weeds, it is more economical to use power sprayers with an experienced spray operator, and arrangements are made accordingly. However, it is our purpose to control these patches before they get too large.

In this same connection we are using soil sterilizing chemicals to keep weeds and grasses of all kinds from growing under a limited number of our timber bridges, to reduce the fire hazards to such property. This is being done for the purpose of evaluating the cost as between the chemical application and the regular hand method.

With this in mind, the Association of American Railroads has made available to the Iowa State College a grant of money to be used in research work for weed control on railroad right-of-way. We know their findings will be effective and practical. Other individual American railroads are working closely with chemical companies, using a wide variety of herbicides to determine their value. With increasing labor costs, efficient mechanical means must also be devised to insure the greatest return on time and money invested. Our request therefore, to the chemical industry is for a chemical that will kill weeds and not grasses, one that has a minimum of drift hazard, is not poisonous nor a fire hazard and is economical to use.

In conclusion, let me reiterate our strong desire to work with all agencies, such as Agricultural Colleges, chemical companies, state and county regulatory bodies toward the end that we will all benefit from our cooperative efforts.

SUMMARY

Railroads have long been conscious of the need to control noxious weeds on their property. They know their prosperity coincides closely with the prosperity of the territory they serve. If the farmer isn't prosperous, then the railroad serving the area will soon feel the pressure of lower incomes.

Our regulatory bodies, namely our Weed Commissioners in the various states, have been most cooperative with the railroads in their effort to effect good weed control measures.

The Milwaukee Road, comprising nearly 11,000 miles of line in 12 states, has many and varied problems associated with control of weeds. For our road bed section proper, our weed and grass killer has been a formulation of 10% creosote and 90% high flash diesel fuel. Throughout the years it has proved successful, but new and improved chemicals have been tried and no doubt will receive greater attention in the years ahead.

For the control of noxious weeds, such as leafy spurge, Canada thistle, field bind-weed, perennial sow-thistle, hoary cress, etc., we have used various formulations of 2,4-D. The most effective, perhaps, is the ester. What the railroads are looking for is a herbicide which can be used in the killing of weeds, and not the grasses, with a minimum of drift hazard. It is also essential that the chemical to be applied on the right-of-way is not poisonous, nor a fire hazard, to the men and to the property.

The Association of American Railroads has made available to Iowa State College a grant of money to be used in research work for weed control on railroad right-of-ways. We know their findings will be effective and practical. With increasing labor costs, efficient mechanical means must also be devised to insure the greatest return on time and money invested.

PENDING WEED CONTROL LEGISLATION

Charles Gilbert, State College, South Dakota.

At the Eighth Annual Meeting of this conference held at Oklahoma City in 1951, the regulatory section adopted and sent to the conference as a whole, a resolution to the effect that congress be memorialized to pass legislation to prevent federal agencies from violatin state laws and particularly State Weed Laws. The resolution was later adopted by the entire conference.

The writer was instructed by your chairman of the regulatory section to follow the matter and we sent rather detailed instructions to the secretary of the conference as to the handling of the resolution. Assuming that it was being done, no further action was taken until spring when we learned that the secretary had done nothing. In response to our inquiry as to why, he stated that he had written me on January 7 explaining his reasons. At our request, he sent me a copy of a letter he states he sent me. This arrived sometime in May. The original was never received.

We immediately proceeded to supply members of congressional delegations from this area with the resolutions and asked our regulatory people to further contact them.

We also asked that the matter be brought before the national meeting of state secretaries and state commissioners of agriculture at their annual summer meeting.

As a result, we were able to get introduced, companion bills in the House and Senate at Washington covering this matter. They were referred to committees with very favorable support. However, because Congress adjourned early, no action was possible.

The annual meeting of the secretaries and commissioners of agriculture gave a strong endorsement of the proposed legislation.

It now remains for the proposed bills to be again introduced again submitted to committee and again considered. There seems to be no doubt that the delay in presentation was the prime cause for the bill not being on the federal statute books at this time.

The Senate bill is numbered 3382 and was introduced by Senator Mundt. The house bill is numbered 8357 and was introduced by Congressman Lovre.

The wording of the two bills was identical. It would appear that all states belonging to this conference should, individually and collectively, immediately support the position taken by the conference, the departments of agriculture, the proponents of the legislation and the bills which we expect to again be introduced. This endorsement should come from members of this conference, local weed boards, county governments, township governments and all others who are interested. If there is any doubt as the importance and necessity of this legislation, reference could be made to the proceedings of last year and the paper entitled "Weed Control on Public Lands".

Abstract of the Banquet Address

"CANADA - AN AMERICAN NATION IN THE COMMONWEALTH"

Hon. Mr. Justice Freedman, Winnipeg, Man.

To a gathering which is made up predominantly of visitors from the United States I should like, as the unappointed but certain spokesman of my fellow Canadians, to pay tribute to the role of leadership which the United States is playing in world affairs. She has become in truth the hope of the free world. In this role of dedicated leadership the United States has had the steady and active support of the nations of the British Commonwealth.

Although the structure of the British Commonwealth -- a unique example of co-operation without coercion -- is becoming better understood, some misconceptions concerning it still linger. For many years the description of the British Empire as "a self-liquidating institution" was regarded in many quarters as an empty phrase. Not least of all in the United States was this the case, and the example of India was pointed to as an instance of imperialism in action. It came as a shock, however, to such critics to find India receiving full independence, and then electing, of her free will, to remain in the Commonwealth, albeit as a republic.

It is central to an understanding of Canada's position in the world to understand that she looks two ways. As a member of the British Commonwealth she is bound to Britain by ties of history and tradition, ties which are real, deep, and evoked in their fullest measure in times of crisis. As an American nation, on the other hand, she is bound by geography and by the bonds of the most cordial friendship to the United States. As a result we Canadians are always happiest when Britain and the United States are in agreement, and it is not necessary to choose between them.

A Canadian spirit is beginning to emerge. The term "Canadianism" has not yet begun to be as meaningful here as the somewhat magical term "Americanism" is in the United States. But it is slowly gathering force. Today Canadianism is recognized as the product of all the forces entering into our expanding civilization. It is French Canada and English Canada in growing mutual understanding and cooperation; it is agriculture and labor and industry producing for us at home and for others abroad; it is our Musical Festivals and the Grey Cup final; it is the national memory of great services rendered in two crucial wars; it is pride in a parliamentary tradition of self-government; it is faith that the future will bring nearer the fulfillment of the Canadian dream.

The following presentations were made at the Conderence Banquet:

NCWCC Industry Committee Awards to:

Mr. E.H. Buckingham, District Agriculturalist, Vermillion, Alberta.

Mr. Andrew T. Olein, County Weed and Seed Inspector, Clarkfield, Minnesota.

NCWCC Honorary Member Award to:

Mr. H.E. Wood, Manitoba Department of Agriculture, Winnipeg, Manitoba.

The Chemical and Allied Industries operating in Western Canada presented Mr. Wood with a scroll, brief case and purse.

SOME NEW WEED PROBLEMS

A.H. Larson, University of Minnesota.

It is only natural that new weed problems should develop as all biological things are in a constant state of flux. With our modern means of rapid and distant transportation it is possible for plants and other life to be carried into every location where they are adapted or can accomodate themselves. In some instances they find more favorable surroundings than in the lands of their nativity, as witness the prickley pear in Australia. This is especially true in regards to weeds whose native enemies have been left behind, or where the systems of farming are more suitable for them. When we contemplate the vast array of our weed population species and the lands of their origin we can readily see that our weed problem is largely one of our own creation; due either to introduction of new species, creation of more favorable conditions for native species or by the changing of systems of farming. So many of our main crops are introduced that it is only natural that weeds that have grown with these crops for ages in their native lands have become so adjusted to their life habits that these weeds were well adapted to their new habitats in America.

In the Arrowhead and Iron Range area of Minnesota three weeds of little significance in other areas are problems because of two local conditions. Much of the level land suitable for cropping is either too wet or too stoney, hence, these areas are suitable only for meadows or pastures. Dairying is an important industry. Orange hawkweed, ox-eye daisy and meadow buttercup have largely taken over and are not eaten by livestock. The area is becoming enlarged so that it extends as far west as Bemidji and south to Pine City. Where tillage is possible they are easily controlled but in moist or stoney areas chemicals seem to be the only resort, but the cost is apt to exceed the value of the returns. MCP and ester formulations of 2,4-D have given best results to date. Not enough data is at hand to develop a good program. At one time Minnesota was a large producer of red clover, alsike clover and hardy alfalfa seed. Four weeds have made it difficult to produce premium seed. A relatively new weed, hoary alyssum, has invaded much of the light soil or outwash area where legumes are necessary to maintain a productive soil, and due to the danger of using 2,4-D where legumes are concerned, and the fact that its seeds can live in the soil for several years, its eradication is nearly impossible. The same is true of field dodder. White cockle and night flowering catch-fly are both resistant to the hormone-like chemicals and their seeds can live in the soil for many years which makes them almost impossible to control in crops that remain undisturbed in a field for 2 or more years at a time. Legume seeds containing seeds of these four weeds are severely docked or rejected entirely.

Wild oats in small grain fields is a serious problem in many parts of the state and especially in the spring wheat growing areas. Several replies dealt with this pest, but none seemed to have the answer.

Leafy spurge is a pest in many areas and especially in the vicinity of the Twin Cities. Although its seeds are seldom found in crop seeds it is widely spread. In areas where bare fallow is impractical or controlled pasturing with sheep is not feasible, control of this weed is nearly impossible with the facilities now available. It commonly grows in timbered areas and waste places. Heavy applications of ester forms of 2,4-D have given some control but new infestations are continually being found. Mourning doves appear to be the most common

spreaders of the seed.

Yellow trefoil, an annual legume closely related to alfalfa is spreading rapidly because at first it superficially appears to be a desirable plant. Its seeds may live in the soil for several years, usually longer than the average farm relative. It is susceptible to 2,4-D in early states of growth. In good soil it may grow so thickly in small grain that it causes the latter to lodge. The trefoil plants are unable to stand alone so their weight is supported by the adjacent cereals, which frequently are unable to sustain them. Since the seed can germinate at most any time during the growing season, applications of 2,4-D are only temporarily beneficial. Its seeds are too often found in clover and alfalfa seed and are not readily recognized by the average farmer. Most farmers fail to realize its significance until it is too well established. Planting infested fields to alfalfa is a help but dormant seeds in the soil **reestablishes it.**

Giant foxtail, Setaria faberii, is a very new weed in Minnesota. It is already quite widely distributed in the south eastern quarter of the state. Too many at first thought it was a very healthy green foxtail. It was evidently introduced from China in millet, and resembles green foxtail but is much larger and more vigorous. Plants can be recognized by the seed as well as by pilose hairs on the upper surface of the leaves. It is difficult to anticipate the problem it presents as in most cases it has all the characteristics of green foxtail plus size, vigor and aggressiveness. Its presence in Minnesota has not been known long enough to gather evidence as to its seriousness nor to investigate methods for its control. I believe Illinois has had the problem for a few years and can perhaps best inform us as to its potentialities and means of handling. In my estimation, year after year and under most all conditions green and yellow foxtail make up one of the farmers most serious weed pest problems. Their relatively small sizes would indicate that they are much less serious threats then giant foxtail which frequently grows six or more feet in height and when kept mowed down will produce seeds within a couple of inches of the ground. Here is a weed that warrants serious attention before it becomes more widely spread and strongly established. Illinois and Kansas report it as being a very serious pest. It would not be surprising to find it in the neighboring states and especially where screenings and scatch feeds are used, especially as poultry feeds. In one instance in Minnesota it became established where commercial feeds were fed to turkeys.

Another weed that is a problem in a specialized habitat is common chickweed. It is able to thrive in cool moist locations and so is not limited to lawns, but can be very troublesome in market gardens on peat soil. An attempt was made to grow head lettuce in the Duluth area on peat soils. The cool moist conditions were ideal but the profusion of Stellaria media ruined the prospects. It blooms and matures seeds throughout the growing season, takes roots at the nodes of the prostrate stems, making it nearly impossible to prevent its vegetative propagation in spite of frequent cultivation and hand weeding.

We have several areas, chiefly south exposures, on grassy hillsides that are becoming infested with St. Johnswort, Hypericum perforatum. It is rapidly taking over where located. It is poisonous to livestock and so reduces the value of such lands that can scarcely be used for other purposes. Chemical applications appear to be the only means of control and that has not been too successful.

Wild carrot is also on the increase in the hilly parts of southeastern Minnesota where only meadows and pastures are practical because of difficulty of tillage and problems of soil erosion. Early spraying with relatively heavy applications of an ester formulation of 2,4-D no later than initial blooming time gives promise. In the meantime, we must realize that wild carrot and Queen Ann's lace are the same plant, so that its further spread as a garden flower will be stopped. The author, this past summer, had an opportunity to observe this weed in meadows and pastures through Kentucky, Ohio, Indiana, Michigan and a part of Illinois. It is a pest of no little significance. Mr. Munn, of the New York State Seed Laboratory, said it was the worst weed in that state, being that it was so widely spread in permanent meadows and pastures where it was difficult to eradicate at that time. Braken or brake fern is a serious pest in much of the cut-over areas of Northern and Central Minnesota and Wisconsin, which have gone quite extensively into the dairy industry. This is a native plant that was of little importance until the coniferous forests were removed by lumbering and the succeeding poplar forests developed. In many of the so-called pastures in these areas, at certain times there is little other herbage than bracken available for cattle food. It is poisonous when eaten in quantity over an extended period and may cause death. We know of no easy successful control other than plowing and intensive tillage. This is hardly possible in many instances.

In some states wild garlic, Allium vineale, is already troublesome and so well established that control is difficult. Dairy people are especially concerned as most milk drinkers do not relish milk with the dilute flavor of garlic. It spreads largely by bulblets or top sets that can retain their ability to grow while in storage for several years. These are often harvested in small grain and are difficult to separate. It is very commonly spread by that avenue. It also produces the usual underground bulbs which make the plant a perennial and difficult to eradicate. Those areas not afflicted should be doubly cautious to see that it is kept out or quickly subdued. It is largely an eastern plant.

Johnson grass, Sorghum halepense, a close relative of Sudan grass was introduced into the United States by an envoy of ours to Turkey. It did so well in North Carolina that he passed it on to a friend, a Mr. Johnson in Alabama, who too thought it so valuable as a forage for cattle that he did much to spread it. Because it is more difficult to eradicate than quack grass and because it is such a good competitor with farm crops it is now one of the big weed problems in the south and is slowly spreading northward. Indiana, Ohio and Kansas informers rate it as a number one weed problem. Intensive bare fallow seems to be the best mode of operation to control it. Its seeds are very common in Sudan seed. Growing **intertilled crops is not** effective as it does not allow for complete tillage.

It might be well to mention about several weeds that are being spread through the flower or garden seed and nursery stock medium. Many of these have attractive flowers and are very hardy (too hardy) in our region. Among these one might mention: ox-eye daisy, often called Shasta daisy; Jimson weed, also called Jamestown lily; Heavenly angels, Angels trumpet, and numerous other names; Flower of an hour; California rose; Bachelor Buttons or the Corn flower of the West; Chufa or yellow nutgrass, Japanese hops, Princess feather, Cypress spurge, etc. Most folk are aware of the results of the introduction of common barberry. It should be an object lesson.

Several of my informers called attention to three weeds now quite well established in areas farther west and of lesser rainfall. These are:

hoary cress, also called perennial peppergrass, and whitetop, of which there are two distinct types or species: Cardaria draba and C. hymenophysa, but equally bad weeds: Russian knapweed and Poverty weed (**Iva axillaris**). All of these are very persistent perennials with deep root systems, well adapted to regions of limited rainfall. We have some of them in Minnesota and their eradication is difficult.

Other plants which have given indications of becoming pests in our region are:

1. Pignut, Hoffmannseggia densiflora, a fleshy rooted perennial difficult to eradicate and found in areas of low rainfall.

2. Buffalo Bur, Solanum rostratum, an annual tumbleweed that grows much like Russian thistle but armed with numerous spines. Its seeds can live in the soil for at least 10 years, and the plant is tolerant to 2,4-D.

3. In small grain areas Tartarian buckwheat, Fagopyron tartaricum, is an agressive weed. Five-hook Bassia, Bassia hyssopifolia is spreading rapidly in areas of low rainfall.

4. Climbing milkweed, Gonobolus laevis, a persistent perennial, is difficult to eradicate in much of the Great Plains region.

5. Bur sage, Franseria tomentosa, is a serious weed along river valleys in the Great Plains region. Tillage, aside from bare fallow is not effective in its control and in pasture and range areas it is not eaten.

6. In some areas whorled milkweed is on the increase in light or dry soil. It is poisonous, especially for sheep, and warrants attention.

7. Halogeton glomeratus is causing much apprehension in the west especially in relation to sheep grazing areas. It grows in regions of 8 to 15 inches of rainfall and is most apt to appear in over-grazed range lands. It is now widely spread in California, Nevada, Utah, and Idaho and can be found already in parts of Colorado, Wyoming and Montana. A big attempt is being made to eradicate it. It has possibilities of being able to grow in the western parts of the Dakotas, Nebraska, and Kansas. A word of caution would not be amiss.

This list of potential weed pests is getting rather long. It is quite obvious that there are many with problems to consider other than these associated with the so-called noxious weeds such as field bindweed, quackgrass, hoary cress, leafy spurge, perennial sow thistle, etc. There are not doubt many avenues by which new plants with weedy tendencies can enter and it is more than likely, plants which at first appear to be innocuous may eventually gain momentum and become serious problems. Too often people pay little attention to newly introduced plants until they have become so well adapted and established, their eradication is a major project. Leafy spurge is an example. For many years it remained in the background. Now it is of major significance. From a philosophical standpoint our weed problem might be said to be due to three qualities or states of man: 1. Ignorance, lack of information as to the identity and characteristics of a new weed. It is possible that the average farmer is not burdened with botanical knowledge. 2. Indifference is a condition that is quite condusive to the development of weed problems. Thinking that weeds are not troublesome until they are strongly entrenched and require extra efforts to suppress them is a common occurance. 3. Inertia, the tendency of man not to change from old ineffective efforts to new and effective practices, in other words, habit. These might be called the three I's of the weed problem.

I wish it were possible to furnish the solutions to substantially reduce the economic drain of weeds upon agriculture, but that is impossible. I can only stress that whenever new or strange plants appear, one should be critical of them until they have demonstrated their capability. It is much easier to control them when present in limited amounts. I hope you will take time to evaluate each new plant before it poses a weed problem.

CONTROL OF WEEDS HAZARDOUS TO HEALTH

B.H. Grigsby
Michigan State College and
Division of Weed Investigations, BPIS&AE

Weed growth may present appreciable threats to the health of man in one or more of three ways. These are: (1) illness caused by the eating of plants that contain known poisonous compounds: (2) dermatitis caused by skin contact with certain plants; (3) allergic responses produced as a result of contact with pollen or other plant parts. For the purpose of this discussion, only those plants causing contact dermatitis and pollen allergies are to be considered.

In the field of pollen allergy, the fact that any plant that produces pollen may cause an allergic response if that pollen is placed on the mucous membranes of an individual who is sensitized to the pollen in question is generally accepted. However, only from 5 to 10 percent of the total population appear to have pollen sensitization and, fortunately, only a small number of plants are considered to have major clinical significance. In the area included in the NCWCC, ragweeds (Ambrosia spp.), marsh elders (Iva spp.), wormwoods (Artemisia sp.), pigweeds (Amaranthus), Chenopods (Chenopodium, Salsola and Kochia) and about 6 genera of grasses are the most important hay fever producing plants.

All these plants are of widespread distribution and, with the exception of the artemisia group, generally are associated with rural city and urban situations where soil disturbance is frequent. Wooded and range areas are relatively free from the majority of the above species.

The basic facts of the relationship between pollen and hay fever have been known for many years, but prior to the advent of the use of 2,4-D for weed control, there was but little effort toward the control of weeds as an aid to hay fever relief. Sporadic ragweed pulling campaigns were sponsored in various cities but the chief value was publicity for resort agencies. The successful use of herbicides for weed control in agricultural lands, at a cost which was not prohibitive, lead to an increased interest in the possibility of using similar methods for control of weed health hazards. Hand-pulling, mowing and other mechanical methods had not produced satisfactory results in reducing pollen pollution of the air.

In 1945 a report on results from chemical sprays of various weeds suggested that pollen production could be prevented by relatively small amounts of 2,4-D. Within the next 5 years, New York, Detroit, Chicago, and other smaller cities set up ragweed spray programs. The state of New Jersey has attempted to establish a coordinated state-wide ragweed control program. Some of the eastern Canadian provinces have also established control programs of various magnitudes.

In general, these programs are joint endeavors by municipal health, recreation and maintenance agencies, as well as various civic organizations. Crews specially trained and instructed in the potential risks of widespread application of 2,4-D have

treated several thousand acres of vacant city property.

The available reports from all areas are in agreement that a concentration of 0.1 to 0.2 percent 2,4-D is satisfactory for the control of ragweed when applied prior to the time when pollen release is initiated. This concentration is generally applied in from 75 to 200 gallons of water per acre, or in limited areas of weed growth enough is applied to wet all weed foliage.

Results obtained from these applications usually are satisfactory in that ragweed is killed and pollen release prevented. A few reports have indicated that giant ragweed may produce regrowth and release pollen at a date somewhat later than is normal for this plant. (This effect has been observed in two seasons in the city of Detroit by the writer).

Ragweed spray programs appear to reduce the amount of ragweed plants within a sprayed area in subsequent seasons. Spraying, however, has not brought about the eradication of this plant in any area. Enough seeds are buried in the soil to provide for continued ragweed growth. The elimination of growth for a season, however, does encourage the development of more desirable ground cover. Grasses tend to reduce the amount of ragweed which will develop in uncultivated areas, consequently any city which undertakes a ragweed spray program finds that the total area which should be sprayed becomes smaller year by year. Some areas require retreatment, but these generally are not extensive, except when considerable soil disturbance has occurred.

Pollen records do not show as favorable picture as that indicated by visual observation of sprayed areas. Some reductions of pollen in the air have been reported for one season, but this effort cannot always be expected. Ragweed pollen is light in weight and may be carried in the air for distances up to 400 miles. Thus, there is little reason to anticipate that a thorough spray program within any area will eliminate all ragweed pollen in the area. Nevertheless, it is generally believed that the destruction of ragweed in the vicinity of densely populated areas will have direct effect in reducing the incidence of hay fever in such areas. This effect probably is much greater than can be predicted from pollen counts of the upper air.

The cost of ragweed spraying on city property is considerably greater than for equal areas of farm lands. In 1950, the city of Detroit sprayed 1740 acres at a cost of $6.88 per acre, in 1951, an area of 2192 acres was treated at a cost of $5.22 per acre, and it is expected that the unit cost will decrease as the area sprayed is increased, but a cost of $5.00 per acre is not considered excessive.

The other broad-leaved species mentioned previously can be controlled in the same way as ragweed. However, the occurrence of these species is less frequent and no organized control programs have been undertaken.

Control of poison ivy in cities usually accompanies ragweed spray programs and is often undertaken by park boards as a separate project. Poison ivy is also a problem on highway and utility rights-of-way as well as a farm health hazard. In fruit growing sections, pickers may refuse to harvest the crop from trees under which ivy is present.

Control measures for poison ivy depend upon the location of the ivy and the expected use of the area. Sprays of ammonium sulfamate when the ivy is in full leaf are, perhaps, the most widely used method. Foliage sprays of the ester form of 2,4-D are frequently suggested.The use of 2,4,5-T has given more uniformly satisfactory results than 2,4-D sprays. Either of the two latter compounds may, in some seasons, only produce defoliation and retreatment the following season may be required. In Michigan, sprays applied in June and August have given better control than similar sprays in July and September.

Dormant applications of 2,4-D in oil have given very satisfactory control of poisnn ivy. For such use, 1 to 2 quarts of 2,4-D ester in 10 gallons of fuel oil is a satisfactory solution. Enough of the mixture to coat all ivy stems must be applied. Dormant treatment is especially useful in orchards, but the operator must be careful to keep the spray away from the trunks of fruit trees and any root sprouts from these trees.

Ivy growing on the trunks of roadside trees presents a difficult problem, but can be controlled by carefully cutting the ivy stems at ground level in early spring and then spraying the sprouts as they appear during the growing season. Either ammonium sulfamate or water suspensions of 2,4-D may be used. The oil-2,4-D mixture should not be used because of the danger of penetration of the bark of the tree and subsequent injury or death of the tree.

Applications of CMU, borates and other soil sterilants are of value in the control of ivy along rock walls and other inacessable areas where desirable plants are not present.

The treatments that have been suggested for ivy control are more costly than the usual herbicidal application. However, they are much less expensive than a severe case of ivy poisoning may be and are justified as a means to preserve health of farm labor, children and the general public.

Poison sumac, found only in swampy areas, thus of concern chiefly to hunters and fishermen, will respond to the same treatment as poison ivy. Foliage sprays of 2,4-D, however, seldom kill well established clumps of sumac.

The knowledge now available on the effects of herbicides upon weed plants is sufficient to warrant setting up procedures for use on the common plants which are health hazards. Such procedures, undertaken by competent agencies, can give measurable relief for large numbers of people. These are not miracle workers, however, and common sense, with respect to the results that can be expected must be applied along with the herbicide.

PREHARVEST SPRAY AND CROP DESSICANTS

F.W. Slife, University of Illinois.

The use of preharvest sprays and crop dessicants to aid in the harvesting of crops is becoming more important. Although research on this use for weed chemicals is somewhat limiting, the results to date are encouraging and good enough that recommendations are being made on some crops.

In this North-Cnetral Region, these chemicals can be used for the following purposes:

1. As a pre-harvest sprays to dry up green weeds in mature crops.

2. As dessicants to dry up the green leaves and stems on crop plants that have matured their seed so that harvest can be speeded up.

In so far as pre-harvest sprays are concerned it should be pointed out that this is not the most

important time to be controlling weeds and it seems logical that we should spend our time and effort in trying to control weeds early in the growing season rather than after they are mature. However, in spite of our best efforts, we cannot consistently control weeds early in the season every year and therefore there is a place for preharvest sprays.

Of the types of chemicals tested, contact chemicals have been most reliable due to the size and types of weeds encountered in this work. Oil base contact chemicals such as dinitro and pentachlorophenol have been rather thoroughly tested for this work and have proven satisfactory in so far as week drying is concerned. Water base materials such as endothal, mono chloroacetate, sodium cyanamid and chlorate and borate mixtures have not been extensively tested and further work is needed to evaluate these chemicals for this purpose.

Crops where pre-harvest sprays can be used are soybeans, flax and perhaps small grains. Although 2,4-D applied as a pre-harvest spray to small grain has generally been successful, poor results have resulted due to the advanced stage of growth of the weeds. It would seem that contact chemicals would be more reliable than 2,4-D for this purpose.

The need for pre-harvest sprays will probably vary from season to season but it should be of considerable importance each year.

The use of chemicals for crop dessication is the 2nd phase.

The idea behind this type of treatment is to kill the green leaves and stems of crop plants that have matured their seed.

One of the biggest uses for crop dessicants seems to be for legume seed crops. The standard practice has been to mow down the seed crop and then pick it up from the windrow. This has several disadvantages over direct combining. There is some loss of seed in the mowing and windrowing operation and if it rains while the seed is in the windrow the seed loss is usually substantial.

The use of pre-harvest sprays had made direct combining possible in most cases.

In a series of tests carried out in Kansas by C.O. Grandifield on alfalfa, in all cases more seed was harvested from the chemically treated plots than from plots cured in the windrow. This increased seed yield more than paid for the treatment.

J.W. Zahnley from Kansas has reported that pre-harvest spraying of sweet clover is extremely promising and in his tests seed yields from treated plots were consistently greater than the plots mowed for curing.

N.E. Shafer from Nebraska has also obtained excellent results with alfalfa dessication even under rainy conditions. Oil base chemicals applied under these conditions made direct combining possible whereas in some cases it was too wet and rainy to even now the alfalfa for windrow drying.

J.T. Medler working with endothal at the Wisconsin Station has obtained excellent results in chemical curing of seed crops of Ladino, red, sweet and alsike clovers in addition to alfalfa and birdsfoot trefoil. His work is especially encouraging in view of the fact that seed harvesting in this area is frequently interrupted by rainfall.

It would seem from the experiments conducted to date that chemical drying of legume seed crops will become a standard practice in the seed producing regions. Even though increased seed yields usually pay for this treatment over windrowing, it is a good hedge against wet weather than can cause a complete loss of seed to windrowed seed crops.

Mr. George Cooper from Illinois Station has obtained some interesting results on both corn and small grain crops.

The work on small grains was done here in Canada this fall. He had tried to time his chemical application so that no yield reduction will result and yet soon enough so that the chemical will kill the plant and help reduce the moisture content. In Canada where early fall snows may bury the small grain crop before harvest a few days or a week earlier harvest than normal could mean saving the crop. His results are encouraging and further work is planned for the coming year.

Mr. Cooper's corn dessication work is also promising in that some speed-up in harvest has been obtained without yield reduction by using chemicals. Demand for this practice would be substantial if continued research proves it feasible.

The results from pre-harvest sprays are greatly affected by methods of application. Neither air nor ground application can be recommended for all situations but it seems that the height and density of the foliage should be the determining factor. Planes equipped to deliver between 5 and 8 gallons of solution per acre have been doing an excellent job even in rather dense stands of crops and weeds. Planes delivering less than this have given varying results.

It appears that ground application is preferable if weeds and crops are extremely thick. The greater volume delivered by ground equipment can be given adequate coverage in these situations and give excellent results.

In summary, it appears that pre-harvest sprays are going to be very important on certain crops in our North-Central Region. The demand for pre-harvest spraying of weeds will probably vary from year to year, but crop dessication, particularly on legume seed crops, should be a large steady use each year.

A BALANCED WEED CONTROL PROGRAM

Lyle A. Derscheid, Brookings, South Dakota.

When I was asked to speak on the subject of "a balanced weed control program" I was at somewhat of a loss to what was expected of this subject. I discovered, however, that one of Webster's definitions for the word "balance" is " a state of equipoise, as between different elements." I also learned that one definition for " program" is " a brief outline of the order to be pursued". I, therefore, concluded that the title of this paper could be defined as " a brief outline of the order to be pursued in maintaining an equipoise between different elements in the field of weed control". I realized then that I was not only expected to mention different elements involved in controlling weeds, but that I was to briefly outline the sequence in which each element was brought into play.

As I attempted to visualize the different elements that are to be kept in proper sequence and proper balance, I was confronted with the problem of deciding whether the program was to be designed for a farm, a state, a region, a nation or the world. I felt that a regional conference probably should not be concerned with a program for a nation or for the world, but should be concerned with a program for a region or perhaps a state or province. I took the prerogative, therefore, of deciding that the program, in this case, should be designed for a state or province. After all the same type of program could be used for a larger area with the right kind of coordination.

It seems to me that every successful weed control program must include the four elements of education, research, organization and regulation. Some might argue that industry is a fifth element to keep in balance. It cannot be denied that industry plays a vital role in any weed control program by furnishing sprayers, chemicals, cultivators and other material needed to control weeds. My contention is, however, that all of the work done by industry, in promoting a weed program, can be classified under one of the four elements--education, research, organization or regulation.

Before the leaders of any program can utilize these four elements, they must realize that any program that involves so many people in a democracy, such as ours, must be on a voluntary basis before it can be entirely successful. We in the United States and Canada are proud of the fact that we have the freedom to think, speak and worship as we please and few of us would subscribe to a compulsory program. Without the whole-hearted support of a majority of the people, any program is doomed to defeat within a relatively short period of time. We have been allowed to develop individual initiative and we are all striving to better our positions in life. If we can see that we can better ourselves by controlling weeds, we will control them. This requires education and research.

Weeds know no bounds and will spread from farm to farm , from township to township, from county to county, from state to state, and from nation to nation. They are disseminated by wind, by water, by animals and by man. They will encroach upon rich agricultural land from game preserves, from forestry preserves and from rights-of-way. They will thrive in the wide open rangelands, and they will raise havoc with gardens or lawns. In fact weeds will grow almost any place they are not wanted and they will invade from any place they are not wanted. This means that an individual landowner has a very difficult time of freeing his premises of weeds if the adjacent landowners are prone to let their weeds grow and spread. A weed control program, then, is a community problem and cannot be solved without a coordinated effort. Such a coordinated effort requires organization.

If we will concede that a good program must be on a voluntary basis and that weed control is a community problem which can be solved only by a coordinated effort of all landowners, we are ready to put education and research to work. These two elements must work hand in hand. The research workers must obtain the information that the educators pass on to the landowners. The first objective is to show the landowners that weeds are destructive, show them that weeds depress crop yields, show them that weeds decrease the palatability of their forage, show them that weed seeds reduce the value of their grain, show them that weeds cost extra cultivations and hamper harvesting operations, and show them that weeds often require more soil moisture and soil nutrients than their crops.

This team of research and education can show the landowner that such annual weeds as cockleburs, sunflowers, lamb's quarters and ragweed require 432, 705, 801 and 948 pounds of water, respectively, to produce one pound of dry matter. This is considerably more than the 368 pounds of water required to produce one pound of dry matter in corn or the 513 pounds for wheat, 534 pounds for barley, 597 pounds for oats or approximately 300 pounds for sorghum or millet. In fact it can be shown that the amount of water required to produce ½ ton of cockleburs, and it is not uncommon to raise more than ½ ton per acre, is sufficient water to produce 8 bushels of oats, 7 bushels of barley, 4 bushels of wheat or 9 bushels of corn. The amount of water required to produce ½ ton of sunflowers or lamb's quarters is sufficient to produce 50% more of each crop.

Weeds not only use more water than our small grains, but they use from 50 to 100 per cent more nitrogen and phosphorus. As much as 24 bushels of oats, 19 bushels of barley, 12 bushels of wheat or 16 bushels of corn could be produced with the amount of nitrogen and phosphorus required to produce ½ ton of lamb's quarters. Even more grain could be produced with the plant food needed to produce ½ ton of wild oats, mustard or pennycress.

This first phase of the program is a very important one and requires a lot of time and patience. The amount of time spent on this phase often means the difference between the success or the failure of the entire program. In our state this job of education fell largely on the shoulders of our county agents. Many times they were confronted with such remarks as --" creeping jenny isn't a bad weed, why if it hadn't been for creeping jenny we wouldn't have had anything to feed our cattle in the thirties" or "my father got along with the weeds, I guess I can" or "weeds make the land more fertile" or "I don't bother about weeds, because they keep coming down the creek from John Jones' place". Those people needed education about weeds. They needed to know that they might have had good feed for their cattle if it had not been for creeping jenny; they needed to know that weeds cannot put more nutrients into the soil than they take out and they needed to know that through organization John Jones' weeds would no longer bother his neighbor. Yes, this phase of education is very important and where it was well done, we now have good programs.

After the landowners have been convinced that it costs more to keep weeds than to control them, a third element, organization, is brought into play. It seems to me that the logical place to start organization is at the community level because weeds are a community problem. There are undoubtedly several methods of accomplishing this mission--the important feature, however, is that organization be complete. We cannot be concerned with just a few

owner-operators, but we must be concerned about absentee landowners, game preserves, Indian lands, forestry preserves, railroads, township and county roads, state and federal highways, and all other privately or publicly owned land. We should not only include all rural landowners, but all urban landowners as well. We should enroll all the people.

The system used in our state seems to be working satisfactorily and I will present it to you as one method of securing organization. A separate organizational meeting is held in each community, which usually consists of one or more governmental subdivisions, such as a township or townships or municipality, or some other sub-division such as P.M.A. district. Each community group elects its community weed representative and the community is divided into neighborhood groups consisting of a few individuals (5 to 10 farmers in many instances.) A neighborhood leader is selected in each group. All community representatives of a county meet and elect three men from their number to serve as a county weed board. This procedure of eledtions follows our concept of democracy and we believe that a weed board that is elected can get better cooperation that a board whose membership is determined in some other manner.

The community weed representatives are charged with the responsibility of advising with the county weed board and assisting with the direction of the county program which is outlined by the board. The county weed board is charged with the responsibility of formulating and directing the weed program within the county in conformance with policies set up in the state program. In fulfilling their duties the county board must survey the local situation and decide on the most feasible plan to be adopted for the county. In so doing this board cooperates with all private, state and federal agencies concerned with weed control.

Perhaps the most important feature about organization is its effect on public opinion. To illustrate this point I would like to tell you about an incident that took place in South Dakota. Our State Weed Supervisor, Charlie Gilbert, was the star of the show, so I'll tell this story the way he told it to me. It seems that a certain community in one of our central counties was having trouble with one particular farmer. He had promised to clean up his noxious weeds for two years but had done nothing about it. One day the community representative called on him and was chased off the place with a neck-yoke. After several of the neighbors heard about this incident, they decided to petition for enforcement of the state law. They called Charlie and he went down. The county agent, the chairman of the county weed board, the community representative and several neighbors went along with Charlie to give him some moral support.

After they reached this non-cooperators farm, they spent some time reviewing his history of poor cooperation, his negligence, his unfairness to his neighbors, to his land and to his income. Finally he was asked if he were a good enough farmer to take care of his noxious weeds or did he want the state to do it at his expense. He asked how they wanted the job done and was told that they didn't care how he did it just so he did it and did it now. He looked around at the grim faces of his neighbors and finally said "O.K." What's more he did.

The point that I want to bring out is that through organization, public opinion was brought to bear on this farmer. His pride and his desire to get along with his neighbors caused him to voluntarily take care of his weeds.

The second phase of education and research enter the picture after organization is underway. Prior to this time these elements have been concerned with the reasons why weed control is necessary. Now they attempt to learn and teach weed and weed seed identification, methods of preventing weed infestation, methods of eliminating existing infestations and methods of preventing reinfestation of areas on which weeds have been eliminated. They should not only discuss methods but they should include various techniques and principles involved in these methods.

Most of us are guilty of placing too little emphasis on the weed and weed seed identification of this phase of education. We can talk for days about the necessity of planting clean seed, but what good will it do if the farmer cannot identify the weed seed? We can discuss the hazards involved from feeding weedy hay or from using weedy straw for bedding, but what have we accomplished if the farmer cannot identify the weeds? We can outline a dozen methods of controlling a certain weed, but our time is wasted if the farmers do not know what the weed looks like. I cannot overemphasize the importance of teaching weed and weed-seed identification. We do not have to limit ourselves to adults, we can teach this to youngsters. In South Dakota we have a special 4-H project in weed identification. Many of you have already seen some of these weed collections on display here at this conference.

In winter meetings we can stress the importance of the use of clean seed, the use of clean machinery, the value of good crop management and crop rotation practices and the need for covering vehicles that haul weedy feed or seed. We can discuss the use of competitive crops and why some crops are better for controlling weeds than others. We can explain the use of chemicals and special tillage practices.

In the spring and summer, we can hold field tours, sprayer calibration schools and demonstrations, and we can help individual farmers. In South Dakota our Extension Weed Specialist, Lloyd Wilson, held a series of schools for county agents in which he explained how to put on a demonstration of chemical weed control on perennial weeds. He furnished the agents with a plot plan, he furnished chemicals and he calculated the amount of chemical to put on each plot. We now have many of these demonstration plots in the state. Farmers can see them and understand what chemicals will do.

This past year we put out a series of demonstration plots on flax in the eastern part of the state. We used 2,4-D, MCP,TCA and mixtures of these chemicals. We made certain that we left an untreated plot at each location. County agents showed these plots to groups of farmers on field tours. Many farmers have decided to use MCP and TCA next year for the first time and one county agent said that this demonstration was directly responsible for the sale of thousands of pounds of TCA for foxtail control in flax.

Our county weed supervisor, Jim Dawson, in Spink County was driving down the road one day and observed a farmer spraying a 70-acre field. He had 20 acres sprayed but his boom was bouncing up and down, indicating that he was travelling too fast. Jim stopped and asked him how fast he was driving. "Four miles an hour" was the reply. They clocked him at seven. He was putting on ½ of a pound of 2,4-D acid per acre he said. Jim checked his calculation and discovered that he was putting on less than one-half of that amount. The farmer finished the field at four miles an hour with the desired amount of chemical. He had excellent weed control on 50 acres and virtually none on 20 acres. If Jim hadn't set him straight, he would have been a disappointed farmer. Now he knows that he can do a good job if he does it right. His field served as a demonstration of the importance of doing the job right.

I talked to a farmer in Lawrence County who had done a beautiful job of killing field bindweed with 2,4-D on summer fallow. After he plowed the field and put it into crop, he was terribly disappointed to see bindweed in his crop. He was through using 2,4-D he said and was going to kill the bindweed once and for all with borascu. He didn't realize that the bindweed came back from seed that was in the soil and that he would probably have the same trouble after the effects of the borascu wore off.

We can even use some of our research plots to demonstrate various methods of controlling weeds. In South Dakota we have a weed field day almost every year. Sometimes this field day is held in conjunction with our regular agronomy field day, but we have had several separate field days on our outlying weed farms. These outlying farms are set up to work on special weeds, such as field bindweed, leafy spurge, Russian knapweed or quackgrass, and field days at these locations always bring in 250 to 300 people that are vitally interested in the particular weed being studied. In this way we are able to get the information to the farmer almost as soon as we get it ourselves.

Even though people realize the importance of controlling weeds and can identify the weeds, some of them will not believe that they can control the weeds with special cropping practices or chemicals. Others expect that one shot of chemical will free them of weeds once and for all. Those that expect one shot to do the trick are disappointed when it doesn't. Some of them get disgusted and quit: others find out through education, that weed control is a long time problem. They are making inroads on their weed infestations.

When education, research and organization have been allowed to function properly, a large majority of the landowners will cooperate voluntarily in a weed control program. However, there will be a minority of non-cooperators that will require regulation. We need this fourth element, regulation, to protect the majority from the minority. Regulation should include the enforcement of laws governing the sale of weedy seed or feed; the movement of threshing equipment, containing weed seeds, in or about the state; the transportation of seed or feed containing weed seeds; the commercial application of herbicides and it should have the authority to force non-cooperators to control their noxious weeds that are encroaching upon a cooperators land.

Two important aspects of regulation are that it be held to a minimum and that it work from the people up to the enforcement agency--not from the enforcement agency down. We had an incident in Hamlin County, South Dakota, where an absentee landowner refused to take care of the weeds on her nine quarters of land.The weeds on these farms were infesting the farms of neighbors that were trying to control their weeds. Several letters were written to the landowner by county and state officials. She answered the letters all right and she made a lot of promises, but she didn't promise to control the weeds. The neighbors finally signed a petition for enforcement of the state weed law. She was given another chance to control the weeds voluntarily. She refused so the Secretary of Agriculture finally instructed the sheriff to serve notice to the landlord and to the tenants. The Secretary then had the weeds taken care of and submitted the bill of $287 to the landowner. She refused to pay the bill and hired some high powered attorneys to break the law. After the attorneys had studied the case they recommended that she pay the bill. She still refused, so the bill was added to her taxes. There are isolated cases like this where regulation is necessary, but the regulation comes from the people up to the enforcement agency.

I think that our main obstacles in maintaining an equilibrium among education, research, organization and regulation is our tendency to be in a hurry. We do not want to take time to do a thorough job of education and we want to use regulation before education is complete. If we will temper our weed control program with a little time and patience we will find that we will secure complete education, voluntary cooperation and have little need for regulation.

PROBLEMS IN REGISTRATION OF HERBICIDES

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Since this paper is conerned with the problem connected with the registration of herbicides, it seems advisable to explain what registration is and how problems may arise under it before dealing with some of the specific problems associated with it.

In 1947, Congress passed the Federal Insecticide, Fungicide, and Rodenticide Act. About the same time, and since, many states have enacted similar legislation, generally modeled after the so-called Uniform State Insecticide, Fungicide, and Rodenticide Act. These acts also cover herbicides but because herbicides were included after the bills were otherwise completely drafted, they are not named in the titles.

The Federal Insecticide, Fungicide,and Rodenticide Act regulates the distribution, sale, and, indirectly, the use of pesticides moving in interstate commerce. It is enforced by the Insecticide Division of the U.S. Department of Agriculture. The state acts similarly regulate these products in intrastate commerce.

Both these acts provide that before any pesticides, including herbicides, are offered for sale they must be registered with some designated official, usually the Secretary of Agriculture. In actual practice, the Secretary delegates this duty and responsibility to some member of his department.

To secure registration, the applicant must submit to the responsible official an application for registration accompanied by a statement of the composition of the product which is to be offered for sale and a copy of the labeling which is to be used in conjunction with it, including all claims and directions for use. In the case of established products, this does not involve any particular problem. The enforcing official knows the uses for which that particular product is generally accepted, the manner in which it should be applied and any precautions which should be taken in connection with its use. In such a situation, he merely examines the proposed labeling and, if it follows standard practices, registration is granted. However, the enforcement official does have a right to request data which will show that the product is both safe and efficacious for the purposes for which it is to be sold and always does so in the case of new products just being introduced and in instances where the manufacturer seeks to sell his product for some use for which it is not generally recognized. If the official is not convinced that the data fully establishes the effectiveness and safety of the product, he does not grant the registration and the product cannot be sold. Thus, registration depends upon the ability of the applicant to answer questions posed by officials and satisfy them that he has sufficient data to justify the use of his product for the purposes and in the manner that he intends to recommend it.

With some over-simplication, it may be said that some years ago the only questions asked concerning a new herbicide were: did it kill or control weeds, and could it be handled safely by the applicator. The effect on soil, for example, was generally of no interest: sterilization was often desirable. Today in this era of selective weed killers and their use on and around food crops many more questions are asked and much more information is necessary to answer them and to satisfy the officials before registration is obtained.

Thus, the first problem is a technical one and involves the preparation and execution of a research program designed to develop the necessary data. The exact nature and amount of data which must be collected before a product will be accepted for registration by the control officials will vary somewhat depending upon the proposed uses for it. In general, it can be said that much more information will be required when it is proposed to use the herbicide in or around a food crop than when it is intended for non-food uses. All the various types of data which I will discuss hereafter might not be required for any one new herbicide but on the other hand, in some instances, additional data will be required. However, these are considered to be those points most commonly covered and generally requested.

TYPES OF DATA NORMALLY REQUIRED ON A NEW HERBICIDAL CHEMICAL INTENDED FOR USE ON A FOOD CROP

1. Chemical and Physical Properties

A. Chemical composition.
B. Structural formula.
C. Degree of purity.
D. Nature and amounts of impurities.
E. Solubility in water and various solvents.
F. Vapor pressure and/or volatility.

11. Analytical Methods

A. Macro, for analyzing technical products and formulations containing it.
B. Micro, for determining residues on food crops.

111. Effectiveness

In terms of (a) percentage reduction or control of weeds compared to check plots, (b) increase in crop yield, or (c) other desirable benefits. Normally this data will have to be collected from large scale field tests under different climatic conditions.

1V. Residues

Nature and amount of residues remaining in or on the treated crops at harvest following typical application under varying field conditions.

V. Toxicity.

A. Acute toxicity. Determination of LD_{50} on mice, rates rats and rabbits by oral ingestion, and where pertinent by inhalation, and skin absorption.

B. Chronic toxicity. The effect, if any, of repeated and prolonged exposure to the chemical or food treated with it. Normally requires the daily feeding of the chemical in varying amounts to laboratory animals for a minimum period of two years.

C. Other effects on man or animals. Skin irritation, skin absorption, eye injuries, etc.

V1. Plant Injury

Nature and extent of any injury to crop for which product is to be recommended.

V11. Other Adverse Effects on Crop

Any undesirable changes in appearance, flavor or taste of crop.

V111. Compatibility

Compatibility with other pesticides, if recommended for use with them or in the same spray schedule.

1X. Effects on Soils

Any residual effect on soils which might interfere with the normal use of the soil in succeeding season.

Items 1V and V, Residues and Toxicity, are particularly important since these data are used to determine whether the residue which might remain on the crop at harvest could pose a health hazard to the consumers of the treated crop. The chronic toxicity studies establish the level at which the herbicide may be present in the diet without injury to the consumer. Unless the residue studies show that under normal field conditions the herbicide residues at harvest will be below that level, or that they can be brought below that level by some practical removal treatment, the product will not be accepted for registration, or its use will be restricted to such crops or limited conditions of application that the residues will not constitute a public health hazard.

The cost of obtaining the foregoing information which is a prerequisite for registration, poses a financial problem. Dr. C.O. Persing made a survey of the cost of developing new pesticides among several of the manufacturers of agricultural chemicals and reported his findings in an address delivered before the Fifth Annual Meeting of the Association of Economic Poisons Control Officials in October, 1951. His survey was not restricted to herbicides but covered the general field of all agricultural chemicals. He found that the cost of research on a new agricultural chemical up to and including the pilot plant stage varied from $165,500 to $355,000 with an average of approximately $300,000. A sum of $400,000 had been spent on one new chemical and it was still in the pilot plant stage. Another compound covered in Dr. Persing's survey was abandoned after an expenditure of $150,000. Dr. R.H. Wellman, in an article which appeared in the September, 1952, issue of "Agricultural Chemicals", estimated that the total research and development cost of a successful agricultural chemical amounted to $1,382,000, taking into account the money which was expended on products which were abandoned after a certain amount of time and money had been put into research and development on them. Whereas Dr. Persing's figures are based primarily on the direct cost of the successful chemical, Dr. Wellman recognized the investment in a much greater number of products which are abandoned for various reasons at some point along the way during the research and development program. Such failures are to be expected and their cost must be recognized in computing the actual overall cost of developing a successful product and getting it into commercial production and sale since it took the total amount of research on all the successful and unsuccessful products in order to find the successful ones.

This brings us to the second phase of the problems connected with the registration of herbicides. It has been the unfortunate experience of many companies doing research in this field that, after they have spent a great amount of time and money in obtaining data of the sort previously discussed and believe that they have their product ready for marketing, they encounter unexpected and unpredictable obstacles. When they present their data to regulatory officials in order to obtain registration, they find all too often that some regulatory officials believe that one or two more points should be further investigated before the product is offered for sale. This delays the marketing, possibly for a whole

season, and calls for an additional expenditure to secure the new data. After this data is secured another question or two may be presented, and so on, almost ad infinitum. This difficulty stems from the fact that neither the federal act, the regulations or interpretations issued under it, nor the various state acts similar thereto establish any definite or specific standards which a new product must meet nor any test program which if followed, would form an acceptable basis for registration. In other words, there are not objective standards for determining the adequacy of a test program or evaluating the data obtained; rather they are subjective standards based upon the regulatory officials' interpretation of what the acts require or may require and, as such, are subject to personal and varying interpretation and application depending on any number of factors. The standards set up and applied by any one official will vary from time to time but are generally becoming more stringent as time goes on. This poses a real problem for the manufacturer who is attempting to develop a new product since he can never feel any certainty as to just how much research he must do before he can register his product, how long it will take, how much it will cost, and finally when he can reasonably expect to sell his product. The cost of developing new products and the uncertainty of just when and under what conditions registration may be obtained has already served to discourage research in the field of agricultural chemicals.

Any discussion of the problems connected with the registration of herbicides would be incomplete without consideration of some new problems which may be in the offing in the form of addi--tional regulatory controls.

I am sure that all of you are familiar with the Delaney Committee which was established by the Congress to investigate the use of chemicals in food and cosmetics and I will not spend any time on it now except to say that this Committee concerned itself with agricultural chemicals and fertilizers as well as those chemicals which are added directly and deliberately to foods in order to improve their quality, appearance, shelf life, etc.

This proposed additional regulatory control to which I have just referred was originally presented to the Delaney Committee by a spokesman for the Food and Drug Administration. It was later introduced in the Congress in the form of a bill by Congressman Miller, a member of the Delaney Committee. Congress did not act upon it and it died with the adjournment of the Congress a few months ago. However, Congressman Delaney, Chairman of the Committee, has stated that legislation along similar lines will be introduced into the new Congress which convenes in January. Hence, we may properly look at the bill which was introduced last year as a basis for anticipating what may be introduced next year.

In substance, the Miller Bill, as it is called, would prohibit the marketing of any "chemical additive" in interstate commerce unless it were first approved by the Food and Drug Administration. Moreover, food bearing any "chemical additive" for which this permissive approval were not given, would be deemed adulterated under the Act. The term "chemical additive" is defined at length in the bill and includes pesticides intended for use in producing,processing, packaging, or holding food,"if such use is likely to result in contamination of such food". Thus, herbicides intended for use on or around food crops would fall within the scope of this bill.

Under the precedure specified in the Miller Bill, to obtain the necessary approval of a new herbicide, the manufacturer or other vendor would herbicide, the manufacturer or other vendor would be required to submit an application to the Food and Drug Administration giving the name of his product, full reports of toxicity investigations, a full statement of the composition, a full description of methods of analysis for the quantative determination of such pesticide in or on food, all directions, recommendations and suggestions proposed for its use and full reports of residue investigations. Unless the Administrator is satisfied that the applicant had affirmatively established that his product had been adequately tested and that such tests have proven the product safe for its intended use on food, he may refuse to permit the application to become effective. There is a provision for appeal through the courts from an adverse order of the Administrator. However, in such a court proceeding, findings of the Administrator as to the facts would be conclusive if supported by substantial evidence, and courts, in reviewing findings of fact which are technical in nature, quite consistently defer to the judgment of the administrative officials charged by law with making the findings and drawing the conclusions therefrom.

In effect, all research pertaining to chemicals, including herbicides, intended for use in or on food or food crops would be subject to review by the Food and Drug Administration. The judgments of its personnel as to the adequacy and interpretation of experimental data would be superimposed on or substituted for those of the chemicals, entomologists, plant physiologists, plant pathologists, toxicologists, or other scientists who had actually performed the research, regarless of their professional ability.

This raises a question as to the future status of the scientists in land grant college, agricultural experiment stations, independent laboratories and other research organizations as regards the making of recommendations for the safe and effective use of pesticides, based upon their own research and that of others. Are they to retain their present degree of scientific and intellectual freedom or are they to be subjected to bureaucratic veto?

The standards which the Food and Drug Administration might apply to new products under the terms of the Miller Bill were indicated by Dr. Paul B. Dunbar, at that time Commissioner, Food and Drug Administration, in his testimony before the Delaney Committee as follows: "I feel that no new chemical or no chemical that is subject to <u>any question</u> as to safety should be employed until its possible injurious effect, both on an acute and/or long time chronic basis, has been shown to be <u>non-existent</u>. In other words, any chemical that is proposed for use ought to be proved in advance of distribution in a food product to be <u>utterly and completely without the possibility of human injury</u>." (Underscoring added.)

Dr. Bernard L. Oser, Director, Food Research Laboratories, very ably commented on such requirements when he said, "The standards of safety implied in these statements are unrealistic because they are humanly and scientifically impossible to comply with. They illustrate a possible trend administrative discretion may take when faced with broad or ambiguous definitions. Such ultimate proof of safety demands knowledge of all possible deleterious effects and is predicated upon the demonstration of safety not merely in 'man' but in 'all men' irrespective of age, sex, dietary habits, physical environment, physiological stress, health, or disease.The day is not in sight when such proof will be possible. Furthermore, how could one logically justify requiring it only on behalf of new chemicals, but not for all chemicals or for foods themselves for that matter?"

As regards pesticides, including herbicides, the Miller Bill would not dispense with the registration requirement of the Federal Insecticide, Fungicide, and Rodenticide Act. It would superimpose what would in effect be another registration procedure with greater room for subjective decisions by the responsible officical and fewer legal safeguards for the manufacturer.

The problem would be further complicated by the fact that with two different agencies more or less doing the same work there would likely be two different standards applied.The manufacturer then would be faced with the necessity of trying to meet th these different standards.

Time does not permit my presenting reasons why this proposed legislation is unnecessary in view of existing legislation or how it would have adverse effects on research and agriculture. However, such information is available on request from my organization.

We do believe that this proposed legislation is a most serious threat to the future of chemical pest control, including the use of herbicides, and will present problems far in excess of those which we are facing today.

We believe that if issues involved in this legislation are brought to the attention of the Members of Congress, they will not pass any legislation which would interfere with pest control and the best interests of agriculture. However, we have reason to fear that this proposed legislation may be rushed through the Congress because of pressure groups who are in favor of it and because of the adverse publicity regarding the use of agricultural chemicals which has appeared in the public press. Accordingly, we urge that everyone interested in the use of herbicides watch for this proposed legislation and study it carefully when it is introduced. We also urge that you present your views to your Congressman and ask him to carefully consider the impact which this legislation might have on the future of weed control. We also recommend that you bring it to the attention of the growers and the various farm organizations.

Those of us who are interested in the use of herbicides should see to it that they are not restricted by unwise and unnecessary legislation.

Isopropyl-N-(3-chloropheny) carbamate (CIPC)

R.S. Dunham, University of Minnesota.

The following response of weeds and crops to CIPC has been obtained from 26 abstracts, letters, and reports of research in 2 Canadian provinces and 8 states. Investigators agree very well that CIPC is effective in controlling barnyard grass (Echinochloa crusgalli), foxtail (Setaria spp.), annual smartweed (Polygonum pennsylvanicum and P. persicaria), and wild oats (Avena fatua). They also agree that it is not effective on lambsquarters (Chenopodium album), and in general, not on pigweed (Amaranthus spp.). There have been variable responses from crabgrass (Digitaria spp.), wild buckwheat (Polygonum convolvulus), and purslane (Portulaca oleracea).

Among the crops, sunflowers, peas, onions, soybeans, red beets, spinach, lima beans, snap beans, and potatoes are relatively tolerant. Dormant cottonwood cuttings, jack and red pine-transplants and young Montmorency cherry trees were uninjured by 20 lbs. of CIPC per acre. Wheat, oats, barley, flax, corn, carrots, alfalfa, and turnips are relatively susceptible.

The selective action of CIPC, however, is quite variable depending on several factors as shown by Freed; Anderson, Lindner, and Mitchell; and Wiese. One of the major factors is soil. Thus, rates that kill certain grass weeds without injury to the crop on one type of soil may be entirely too high on another. Apparently, selectivity is easier to obtain on productive organic soils than those low in organic matter and fertility. Disappearance of toxicity is more rapid as weather becomes warmer except that severe drought halts decomposition. Thus, applications made in early spring remain toxic for longer periods than those made later. This fact may also affect selectivity, especially where time of emergence of weed and crop differs considerably. Other factors that are reported as responsible for varying results with CIPC are moisture conditions, stage of plant when treated, and temperatures high enough to cause evaporation.

Octachlorocyclohexanone and Methyl, Ethyl, and Isopropyl esters of Trichlorobenzoic acid.

E.K. Alban, Ohio State University.

Octachlorocyclohexanone: This chemical has been released as a contact herbicide and has been available for general study during the past two years. It is a product of the B.F. Goodrich Chemical Co. and is supplied under the trade name "Oktone" as a saturated (40%) solution of octachlorocyclohexanone in a petroleum solvent. It is applied at the per acre rate of 0.5 to 1.0 gallon of the commercial product in thirty gallons of Diesel fuel #2, or Stoddard Solvent. Applied at these concentrations, it has been used as a contact herbicide. Control of annual grasses and broadleaf weeds, as well as chemical mowing of perennial grasses and broadleaf weeds, has been accomplished at the above rates.

In general weed control, this chemical has found certain commercial use in control of weeds in and around greenhouses ie. under benches, around walks, and on non-crop land. Applied three or four times per season, it has supplied reasonably good commercial weed control with no damage to adjacent crops.

Its use as a pre-emergence herbicide in crops has been limited to such crops as gladiolus and potatoes, and certain large-seeded crops as sweet corn lima and snap beans. Applied as a delayed pre-emergence treatment, control of annual emerged grasses and broadleaf weeds has been accomplished with no damage to the crop plant. With most- small-seeded vegetable crops, the results have been generally unfavorable. Further studies are required with direct-seeded onions and many of the Brassica oleracea group.

There is some evidence that as the rate per acre is increased five or ten times, the residual effects of octachlorocyclohexanone are increased. However, this chemical used at the lower rates mentioned above must be considered as a contact herbicide with practically no residual effect.

Esters of Trichlorobenzoic acid: The growth-regulating properties of trichlorobenzoic acid and certain esters and salts of this acid have been known for several years. Studies in Florida, Illinois, New Jersey, and Ohio have indicated that the ethyl and iso-propyl esters of this acid may have some value as pre-emergence herbicides in plantings of sweet corn, field corn and gladiolus. There is some evidence from Florida and Ohio Studies that both of the above esters may have some value in the chemical weeding of onions and asparagus. It has been necessary to add a wetting agent (Santomerse S, Joy, etc.) to facilitate the spraying of these chemicals in from twenty to eighty gallons of water per acre. The ethyl and iso-propyl esters have been generally

applied at the rates of five or ten pounds per acre, and the methyl esters at five to fifteen pounds per acre.

The control of annual grasses and broadleaf weeds has been accomplished with the above rates of these chemicals when they were applied as early pre-emergence treatments.Control of emerged grasses and broadleaf weeds has been fair to poor depending apparently on the size of weeds, and prevailing temperature and moisture conditons.

There has been some evidence that the five pound rates of the ethyl or iso-propyl esters of trichlorobenzoic acid can be used in directed post-emergence sprays with onions, asparagus,and gladiolus. The methyl ester of this acid usually resulted in excessive damage to the crops whether applied as a pre-emergence or as a post-emergence spray. Damage to sweet corn, with any of the three esters applied as delayed pre-emergence or post-emergence treatments, resembled typical brace-root malformation and onion-leaf curl associated with 2,4-D or MCP injury.

Pre-liminary studies with the methyl, ethyl, and iso-propyl esters of trichlorobenzoic acid indicate that these chemicals may fit into the chemical weed control program as substitute materials for MCP or 2,4-D or as replacement with certain of the more sensitive crop plants.

Herbicidal Use of Sodium 2,4-Dichlorophenoxethyl Sulfate (SES) and 2,4-Dichlorophenoxyethyl Benzoate (SESIN)

D.D. Hemphill, University of Missouri

SES

Sodium 2,4-dichlorophenoxyethyl sulfate (SES) is a chemical with very limited herbicidal properties as such, but it becomes an effective hormonal type of herbicide after it has been converted to an active form by the micro-organisms of the soil. Conversion is very rapid when soil moisture and temperature are favorable. There is little or no epinastic response when SES is sprayed or dusted on the foliage of hormone-sensitive plants such as tomatoes. Herbicidal action is brought about by absorption of the active form of the chemical by the plant roots.

Injury or lack of injury to a crop or weed is determined by the inherent resistance of the species to hormonal type herbicides and whether or not shallow roots are present to absorb a toxic amount of the effective material from the upper layer of the soil.

SES in its activated state is nearly as toxic as 2,4-D to germinating seeds while its toxicity to roots or to growing regions is considerably less than that of 2,4-D.

The lack of plant response when applied to the foliage permits this chemical to be used as a selective herbicide where other hormonal type chemicals may cause excessive injury due to the absorption of the active material by both the roots and the above ground parts of the plant. The margin of safety on sensitive crops is widened considerably by a chemical of this nature.

The danger of using this material near hormone sensitive plants such as cotton, grapes and tomatoes is at a minimum. Little if any injury results should SES sprays or dusts drift to the foliage of such plants.

Due to the nature of SES it is effective on weeds only in the seedling stage. Best results are obtained by application to clean soil ahead of weed seed germination or just as germination begins. Soil moisture is necessary for its conversion; consequently SES is not effective in extremely dry soils.

SES has proven a very effective herbicide for use in asparagus, corn and strawberries. These plants are somewhat tolerant of hormonal type herbicides, and asparagus and strawberries and corn in the seedling stage do not have roots concentrated in the upper layer of soil where the herbicide is most abundant.

During the past few seasons SES has been tested on a wide variety of crops. In addition to asparagus corn and strawberries, the following crops appear tolerant to pre-emergence, emergence or post-emergence application: Gladioli, potatoes, raspberries, sugar cane, sweet potatoes and several species of seedling, newly-transplanted and established nursery stock.

The pre-emergence use of SES on lima beans, snap beans, soybeans, seeded onions and peas is questionable. Serious injury can result if the herbicide leaches down to the germinating seed or where roots are abundant. With these plants best results are obtained by application of the herbicide after the plants have become well established.

SES should not be used on cotton, cucurbits, egg plant, okra, tomatoes, most shallow planted small-seeded crops and some types of nursery stock.

If applied before or at germination of the seeds SES will control most annual broad-leaved and grassy weeds. Canada thistle and smartweed appear more resistant than other weeds. Established perennial weeds are not affected seriously by this herbicide.

SESIN

2,4-Dichlorophenoxyethyl benzoate (SESIN) is similar to SES in chemical structure and in herbicidal properties and can best be discussed in comparing it with SES. Like SES, plant foliage is relatively tolerant to direct application of SESIN. It is converted to an active state in the soil; consequently it will not control established weeds.

SESIN is less soluble than SES, therefore, it has better residual properties. Abundant soil moisture is essential for conversion of SESIN to its active form, however, and poor weed control has resulted under dry conditions.

It was hoped that the insoluble benzoate portion of the molecule would widen the margin of safety on sensitive crops such as cucurbits, tomatoes, etc., but results have not been as encouraging as desired. At present it is suggested for use on those crops which are tolerant to SES.

The most important advantage of SESIN lies in appreciably longer residual weed control than that of SES.

MALEIC HYDRAZIDE

LeRoy Holm, University of Wisconsin.

One of the most interesting chemicals to appear recently, from a theoretical as well as a practical viewpoint, is maleic hydrazide (MH). Initially we were not very enthused about it's possibilities as an herbicide for we have placed so much emphasis on the theory that our chemicals must "kill" or we cannot use them. Our progress in the

control of perennials on croplands may have suffered because of it.

There are some interesting stories to relate about this chemical but a summary of the present state of our knowledge about the physiological and morphological responses of plants to the compound may be in order.

Apparently we have not decided whether the chemical is a hormone-like substance or a general growth suppressant. We haven't even known whether it is an herbicide. As yet we have had no reports of root initiation, fasciation of stem or root tissues, twisting of petioles, or true epinasty such as we have come to expect when treatment is made with growth regulators.

The response to MH has been very uniform among both mono and dicotyledonous plants. The chemical is picked up readily by both roots and leaves. A general inhibition of growth follows and in many species an almost complete cessation in growth may result without death to the plant. The axillary buds are released from dominance by the terminal meristem and internodes are shortened. Flowering is prevented in many species and there is increasing evidence to indicate that micro and megasporogenesis are seriously interfered with.

From the reports which follow I gather that we may have found another soft spot through which we may endeavor to weaken two of our serious pests in these northern areas. Hill, Burt and Willard at Ohio and Zick and Buchholtz at Wisconsin have used four to sixteen pounds of MH on quackgrass and then plowed the weed under shortly thereafter. In all experiments the land was fitted and a crop was planted immediately. At Wisconsin, where the quackgrass was plowed under two weeks after spraying, the re-growth made by the weed was measured frequently during the season. Control was best early in the summer but very good three months later. This is not the proper medium for the presentation of statistics in quantity but a few are in order because of the remarkable agreement in the results of the two stations. Zick and Buchholtz, at three months had obtained about 40%. 65%, and 80% control with four, eight, and sixteen pounds of MH respectively. Potatoes, sweet corn, green beans and red beets grew very well in the plots.

At Ohio, the quackgrass was also treated in early spring but was plowed under four days later. The corn which was planted and tilled throughout the season made normal growth. Four, eight and twelve pounds gave 40%, 70%, and 90% control respectively. The results are therefore almost identical with those recorded in Wisconsin. Lest these data be judged a rare coincidence it should be pointed out that Willard carried out almost the same experiment on Johnson grass in early summer. There was no harm to the corn and the statistics on control of this weed were very nearly the same as for the control of quackgrass.

Experiments somewhat similar to those just discussed were carried out on Canada thistle in Iowa and Ohio. Syhester treated with eight pounds of MH, plowed the ground and planted soybeans. This provided about 75% control of the weed until late in the season. This was the same control obtained with the use of two pounds of an ester of 2,4-D handled in the same manner. When land was plowed after treatment workers at Ohio observed slow recovery of the thistle and flowering at all rates up to twenty pounds. Leaving the land unplowed appeared to make the chemical somewhat more effective. These two experiments may concern thistles treated at different stages of development, however.

Many of you are aware that MH has shown promise for the control of wild onion and garlic in areas south of here. There is some evidence that one treatment may suffice for a three year period or longer. The mechanism here may be one of the prolongation of dormancy such as we hope to make use of in the commercial storage of onions and potatoes. The United States Food and Drug Administration has approved the use of the chemical for control of onion and in the milksheds of some of our larger southern cities.

Another serious pest on which maleic hydrazide has shown promise is wild oats. Anderson and his students were among the first to report the sensitivity of this weed to MH back in 1950 and 1951. Knowles at Ottawa has extended this work with a considerable degree of success. In his work early varieties of barley, wheat, oats and flax were sown in ground planted to wild oats. When wheat and barley were in the four-leaf stage, the first sprays were applied at one, one and one-half and two pounds per acre. Spraying was continued at intervals of three days until six days after the cereals were in head.

All except the last treatment resulted in almost complete sterility in all cereals and the wild oats. At the time of the final treatment flax was in late bloom and the wheat and barley had been in head for six days. These crops had a very small number of sterile heads. The cultivated oats and the wild oats, which were about to begin heading when this treatment was made, suffered almost complete sterility.

It is apparent that MH causes sterility in cereals before fertilization takes place and that soon thereafter the plant becomes immune to the chemical. Thus the later heading wild oats was hurt while wheat and barley, having passed through fertilization, were not hurt. The data are very good and there is more to the story which we cannot take time to discuss here.

These workers are to be commended for placing the harness on a chemical which may do important work for us. They have been able to do so because they could look beyond an isolated academic discovery to a place in our pattern of agriculture. where that basic fact could perform a service.

N-1 Naphthyl Phthalamic Acid

G.F. Warren, Purdue University, Indiana.

N-1 naphthyl phthalamic acid is a new herbicide that can apparently be classed as a growth regulator. Its type of action and selectivity, however, are much different from that of 2,4-D and closely related compounds. When applied to the foliage of sensitive plants, it severely inhibits growth and causes epinastic responses. When used as a pre-emergence application, root growth of seedlings is greatly restricted and negative geotropism has often been observed.

In most experiments, it has been more effective in killing susceptible species when applied before the weeds emerge. The acid formulation has given better weed control than the imide.

N-1 naphthyl phthalamic acid is not as powerful an herbicide as 2,4-D or MCP but at appropriate rates of application it controls a large number of weed species. Its greatest asset lies in its range of selective action which is different from other herbicides now available.

Cucurbits have been outstanding in their resistance to both pre-emergence and post-emergence applications. Results on cucumbers, muskmellons and watermelons have been consistently good. There have been a few reports of slight injury to certain varieties of pumpkins and squash indicating the need for studying the varietal responses.

Pre-emergence applications have also given good results in less extensive trials on soybeans, lima beans, peas, cotton, asparagus, peanuts and gladiolus. For the control of germinating crabgrass in turf, results have been promising. Crops that are reported to be especially sensitive to N-1 naphthyl phthalamic acid are beets, spinach, parsnips, tomatoes and strawberries.

Among the weeds that appear to be susceptible to this herbicide are several annual grasses, purslane, chickweed, galinsoga, lamb's quarters, pigweed, ragweed, and carpetweed. Limited reports have indicated that nut grass and several other weeds may also be controlled.

REVIEW OF WORK WITH CMU AS AN HERBICIDE

C.J. Willard, Ohio State University.

Fifty-four abstracts were received reporting more or less work with CMU. It was used in almost every conceivable way - as a soil sterilant, as a pre-emergence herbicide in practically every vegetable and field crop, as a control for practically every noxious perennial weed, as a control for scrub oak in forests, and to maintain fire lanes in forest practice. These abstracts came from nearly every state and province in the Conference.

Naturally, with a new chemical used under such a wide range of purposes on such a wide range of crops, the results are confusing and inconclusive. Nevertheless, a considerable number of valuable indications can be drawn. By far the most important one is that it is worthy of a great deal of additional study, and will require such study before many practical recommendations can be made for its use.

An outstanding use for which it seems that CMU could definitely be recommended at the present time, is the one for which the manufacturers have most definitely recommended it; that of a soil sterilant on non-crop lands. This use is exceedingly important. We have been in dire need of a safe soil sterilant which can replace the arsenic and arsenic-chlorate combinations which have been used in humid areas, and the borax combinations which have been used in more arid areas for soil sterilization.

On most soils with most weeds complete prevention of plant growth has required in the neighborhood of 80 pounds to the acre, active ingredient. Once this sterility is established, no experiments have as yet continued long enough to indicate how long it will be before it disappears. Following 80 pounds applied to the surface one year, two states found that the soil was toxic to 12 inches to corn and soybeans in one instance, and to sorghum in another. This constitutes definite proof that despite its lack of solubility, it does move in the soil in toxic quantities. It is our conviction that it could be recommended for the destruction of all plant growth in an area wherever it can be economically used. There have been many experiences of the material being carried by surface drainage waters. Any use of this material for soil sterilization should take this into account.

Its use to eradicate patches of noxious perennial weeds parallels its use as a non-crop soil sterilant. We have abstracts discussing its use on quackgrass, Johnsongrass, field bindweed, Russian knapweed, leafy spurge, horsetail, and climbing milkweed. With the single exception of quackgrass, practically all of these weeds require in the general range of 80 pounds per acre for eradication. How soon crop plants can be grown on the area after noxious weeds have been eradicated by this chemical is not yet determined. In the opinion of this reviewer, it will not be feasible to use this material to eradicate noxious perennial weeds on land which it is hoped to put to crops very soon thereafter, because of the long time required for the toxicity to disappear from the soil.

The most promising and extraordinary feature of the year's work with CMU was its wide and varied use as a pre-emergence herbicide. In varying situations it was reported successful as a selective pre-emergence herbicide at rates ranging from .04 of a pound to 4 pounds per acre. There were a few experiments reporting its use post-emergence, which were almost uniformly unsatisfactory. The material is by no means caustic to foliage, but nevertheless seems to do more damage to annual weeds when applied post-emergence than pre-emergence. On the noxious perennial weeds, it seemed to make very little difference whether the tops were treated or not. The effective action seemed in every instance to be through the roots.

As a pre-emergence herbicide CMU is subject to all the problems and limitations of any pre-emergence herbicide. The results obtained from any pre-emergence herbicide will vary tremendously depending on the amount and distribution of the rainfall after the herbicide is applied.This stands out clearly in the CMU reports. Many investigators account for differences in results by differences in rainfall and even where they do not, it is obvious that it has affected the results.

Any pre-emergence herbicide may be greatly affected by the soil type. This, likewise, is obvious in the reports with CMU. On Plainfield sand in Wisconsin 20 pounds to the acre sterilized a fire lane almost 100 percent. On heavier soils it has required 80 pounds per acre to do the same job. In one report on soybeans, 4 pounds to the acre gave 80 percent soybeans killed, on light colored soil. Only about half this loss was caused by the same application on a dark-colored high-organic soil less than 100 feet away.

As with all herbicides, we find conspicuous genetic differences in the response to toxicity of this material. This is true of both crops and weeds. This is independent of differences due to the depth and type of root systems which are also conspicuous.

So much for generalities. Can we get down to particulars? Only slightly. With so many variable factors, and with a material which is so nearly a universal herbicide, it will take much more than the scattered reports of one or two seasons to make any clear recommendations or even statements as to relative toxicity that will hold with any certainty in the future. No plants are really tolerant of CMU. Any large concentration of it will kill all vegetation. Among the crops, however, corn, flax, peas, barley, potatoes, beets, and spinach seemed sufficiently more tolerant than some weeds to be definitely worth working with further. Lettuce, tomatoes, turnips, tobacco, appeared to be among the most easily damaged of crops. In intermediate positions appear to be lima beans, soybeans, carrots, radishes, and oats.

Of the noxious perennial weeds, quackgrass in general seems to be the most susceptible, probably because of its prevailingly shallower root system, and climbing milkweed, leafy spurge, and Russian knapweed to be among the more resistant species. Horsetail, Canada thistle, bindweed, may perhaps be intermediate. Records are altogether too incomplete and unsatisfactory for the above list to be anything but a target for further work to shoot at. Among the more susceptible annual weeds appear to be rough pigweed, galinsoga, wild mustard, wild oats, and wild barley; lambsquarters, green foxtail, purslane, and crabgrass appear to be among the more tolerant weedy annual species.

It is highly significant that CMU was ranked as the most promising pre-emergence chemical tried in a considerable number of tests, with a wide variety of crops. There is no possibility of recommending any of these treatments today; but that they are worthy of wide and careful further evaluation is unquestionable. Among the most significant possibilities are flax, peas, soybeans, corn both sweet and field, and onions.

More and more we are moving toward recommending a particular chemical for a particular weed problem. It is almost impossible to make general recommendations for "weed control" in any crop. Because of the perfectly tremendous variations in individual responses to herbicides, it may be possible to take one weed out of a crop readily, when it would be impossible to use that herbicide to take another weed out of that crop, or to take the same weed out of another crop. This is not very comforting to manufacturers of herbicides, since it means that we will need to use a wide variety of herbicides for various specific and particular uses. Nevertheless, this development seems to be inevitable and important.

OTHER NEW MATERIALS

W.C. Dutton, Midland, Michigan.

This discussion has to do with a few materials on which reports were received but which were not discussed by preceding speakers on this panel. They are B-naphthoxyactic acid, 4-chlorophenoxyacetic acid, trichloroacrylate, sodium isopropyl xanthate and endothal (3,6-endoxohexahydrophthalic acid.

B-naphthoxyacetic acid and 4-chlorophenoxyacetic acid were used on seedling alfalfa (5 to 6 inches high), in oats (about 12 inches tall) at ¼, ½ and 1 lb/A in comparison with 2,4-D, 2,4,5-T and MCP at the same rates. Stand counts of alfalfa made in September show both materials to have caused no reduction in stand. The counts for all rates of 4-chloro were almost identical with those for the check and the same was true of ¼ and ½ lb. of B-naphthoxy and with the count for 1 lb. being only very slightly lower. The only other treatment that did not cause a significant reduction in stand was ¼ lb. of 2,4,5-T. The other two rates of 2,4,5-T and all three rates of 2,4-D and MCP caused severe and highly significant reductions in stand. The theory is advanced, and with evidence to support it, that the apparent toxicity of any herbicidal solution is probably a function of both the retention and absorption of spray particles and the molecular toxicity of the chemical to plant tissues. The 4-chlorophenoxyacetic acid was also used on a second year stand of alfalfa in April when alfalfa was about 4 inches high. This was in comparison with 2,4-D, 2,4,5-T and MCP and all materials were applied at ¼, ½ and 1 lb/A. 4-chloro and 2,4,5-T were much less toxic to alfalfa than 2,4-D and MCP but they tended to reduce yields. The second crop was normal with 4-chloro and 2,4,5-T but was thinned with all rates of 2,4-D and the two higher rates of MCP.

Trichloroacrylate was reported from studies for the control of three perennials:- leafy spurge, Russian knapweed and quack grass. It was used at 10, 20 and 40 lb. on leafy spurge in June and September, 1951 and was ineffective at all rates at both dates. The rates on Russian knapweed were 10, 20 and 40 and 80 lb/A in June and September treatments. All rates were ineffective in June but 40 and 80 lb. in September gave 75 and 85 percent elimination, respectively. The rates on quack grass were 5, 10, 20, 40 and 80 lb/A. Treatments were made to plowed and undisturbed sod in September, 1951 but only the 80 lb. rate on fall plowed sod gave fair results.

Sodium isopropyl xanthate was reported from five experiments, all vegetables. Three of the experiments were with onions, one with direct seeded tomatoes and one with a group of 12 direct seeded vegetables. It is reported to be a contact herbicide with little residual effect. The results in onions were generally poor on all weed species in a normal pre-emergence treatment of 12 and 16 lb. Treatments made 20 days after planting (onions in "knee" stage) caused reduced stand but as a contact pre-emergence treatment was safe and effective. Post-emergence directed sprays on onions gave fair broadleaf but poor grass control without injury to onions. The addition of a wetting agent increased both weed control and crop toxicity. The pre-emergence application of 12 lb. in combination with 3 lb. of TCA on direct seeded tomatoes gave 93 percent control of grasses with no reduction in stand or yield of tomatoes. Pre-emergence application of 8, 12, 16, 20 and 24 lb. was used on 12 direct seeded vegetables. Crop stands were satisfactory with all rates with tomato, beets, radish, carrots, lima and snap beans, sweet corn and potato but was erratic on lettuce, spinach, turnip and onion. Broadleaf control was adequate at all rates, better above 12 lb., but the highest rate did not control grasses.

The last material in this group is endothal for which 20 reports were received and they covered a wide variety of uses and the results were variable and sometimes conflicting. The outstanding indication reported is that it gave fair to good control of wild oats. Fair to good control of broadleaves was usually attained with pre-emergence applications and annual grass control was variable but usually good with 4 to 6 lb. Post-emergence application was only fair on broadleaves and poor on grasses. 32 lb. in a spring application on quack grass gave little effect but the same amount in the fall on fall plowed land gave fair results. Crops apparently are variable in their tolerance to endothal. Onions were generally injured by pre-emergence treatments, tomatoes were severely stunted by 4 lb. and the single report on flax indicated delayed maturity and reduced stand and yield. There apparently were no ill effects on soya beans. Peas and sugar beets were not reported as injured. Red beets were stunted temporarily by 8 lb. in pre-emergence but yield was significantly reduced by post-emergence treatments. Other and very different types of use gave some excellent and some poor results. Excellent weed control was attained and tree growth was increased in newly planted cherry orchards. Attempts to eradicate scrub oak were not successful; an April application was not successful for keeping forest fire lanes open and attempts to keep down weed competition in young forest plantations emphasized the importance of soil type in weed control work. There was excellent control of both broadleaves and annual grasses on loam soil but little control of either on sand and muck. Endothal was not satisfactory for drying soy-beans with heavy stands of weeds.

RECOMMENDATIONS OF THE RESEARCH COMMITTEE, NCWCC

December 11, 1952.

The following discussions, opinions, suggestions, and recommendations are made in the light of the best information accumulated through 1952 by the Research Committee of the NCWCC. The Conference recognizes that the effectiveness of herbicides depend on so many factors which vary from region to region that this report can in no way replace state and local recommendations. It is suggested, therefore, that specific recommendation on the use of herbicides locally be obtained from your state agricultural experiment station, extension service or regulatory officials. The rates of application given for 2,4-D, 2,4,5-T, MCP and TCA refer to acid equivalent.

CONTROL OF PERENNIAL WEEDS

Quack or Couch Grass (Agropyron repens)

For other than small patches cultivation will be found the most effective and cheapest means of eradicating quack. Intensive cultivation should commence during the late summer or fall months. Where soil erosion or leaching is not a problem this to be followed by a black summerfallow which, if given in a dry year will largely eradicate quack. Follow-up cultivation may be necessary. If the fallow year be wet only very poor control can be effected. Heavy pasturing of quack prior to initiating cultivation will facilitate eradication.

Two methods of cultivation are practiced; the use of a disc implement to shred the root-stalks and induce starvation by growth prevention; the use of a cultivator or spring-tooth harrow to bring the root-stalks to the surface where they will dry out and die. In either case the operations must be intensive and continued over a long enough period to free the soil of all viable quack material. Which method is employed would seem to depend on soil type, regional conditions and availability of tillage implements. Important is the extensiveness of the infestation in the field; if in scattered patches the disc implement may be best used as by this means root-stalks will not be dragged to clean parts of the field.

Patches of quack can be eradicated with chemicals. Sodium chlorate may be applied any time, though possibly best in the fall at 3 to 5 pounds per square rod (500 to 800 pounds per acre). TCA is best applied in late summer or fall and is effective at 80 to 100 pounds per acre on undisturbed sod and 25 to 70 pounds when combined with suitable tillage. Cultivation prior to chemical application is more effective than that succeeding. Thorough cultivation is best, such as that given by plough or one-way disc. Complete kill of the quack grass rhizomes may not be achieved; therefore, follow-up cultivation or chemical applications are often needed. In sub-humid regions the residual effect of late summer or autumn applications can be expected to extend into the growing season following treatment.

The chemical, CMU, may be used for eradicating quack on non-agricultural land. Early spring or late fall applications seem most effective. Complete to almost complete kills are obtained by 20 to 50 pounds per acre. Cultivation does not seem to enhance its killing action. More information is required relative to the nature of the residual effect of this chemical. Temporary suppression of quack may be had by early spring application of from 8 to 15 pounds per acre of MH followed 5 to 10 days later by ploughing and working down. Crops sown thereon do not seem affected.

Johnson Grass (Sorghum halapense)

Clean cultivation starting in June or July, and preventing growth for the remainder of the season, will reduce the stand of Johnson grass so as to permit crop production for one or more years. If the area is not subject to winter or early spring floods, winter wheat or barley may be sown and cultivation started after harvest. Heavy pasturing or frequent clipping or a combination of the two will reduce the stand of Johnson grass.

Sodium Chlorate and TCA are effective on Johnson grass. Rates required are: 4 to 6 pounds of sodium chlorate per square rod (650 to 1000 pounds per acre), TCA 3/8 to 5/8 pounds per square rod (60 to 100 pounds per acre).

Field Bindweed (Convolvulus arvensis)

Control may be accomplished by intensive cultivation accompanied by growth of a smother crop. Cultivation to cut off all plants about 4 inches below the surface should be repeated 8 to 10 days after emergence. After the plants have been weakened by this treatment a smother crop should be substituted for the cultivation to reduce erosion and yield some returns from the land. Alternate cultivation and smother crop should be repeated until elimination of the weed has been achieved. Two to four years is required for eradication in the Great Plains area.

Applications of ½ to 1 pound of 2,4-D per acre in late fall or in bud to bloom stage are effective. This treatment usually must be repeated for a satisfactory kill and control of seedlings. Small patches may be killed by the use of soil sterilizing chemicals. An application of 4 to 6 pounds per square rod (650 to 1000 pounds per acre) of dry sodium chlorate followed a year later by spot treatment of any scattered plants that may be left is a practical method for small areas. Borax materials are suitable for locations where the effect on the soil is desirable or not objectionable. The application of dry unrefined material should be at the rate of 10 to 11 pounds of boron trioxide equivalent per square rod. When a soluble form of borate is used it should be applied either dry or as a spray at the rate of 7 to 10 pounds of boron trioxide equivalent per square rod. Mixtures of soluble borate and sodium chlorate also may be used. A two to one mixture should be applied at the rate of 8 to 10 pounds per square rod. Any surviving weeds should be retreated, beginning the second spring after original treatment, until eradicated.

Leafy Spurge (Euphorbia esula)

Intensive cultivation and winter wheat or rye has proved to be an effective method of controlling leafy spruge in areas where these crops are adapted. The area should be plowed early in the spring as soon as spurge plants have emerged and duckfoot cultivated at two-week intervals until fall when the crop is seeded. After the crop is harvested, the process is repeated. At least 2 and probably 3 years are required to obtain elimination of this weed. In areas where soil erosion is not a problem, two years of intensive cultivation alone will often give almost complete elimination.

In many cases, 2,4-D is the most practical chemical available for the control of large infestations and the ester forms are more effective. Top growth of leafy spurge is easily retarded and usually prevented from setting seed in small grain by applications of ½ pound acid equivalent per acre. Where possible, large infestations should be seeded to an adapted perennial grass as its competitive effect enchances the effect of the 2,4-D. Applications of 1 pound twice a year to leafy spurge growing in a

bromegrass sod will often eliminate this weed in 2 or 3 years. Quicker control is obtained if the area is duckfoot-cultivated at two-week intervals for one season before the grass is seeded. Several repeat applications of 1 to 2 pounds made at pre-bud stage will greatly weaken or "thin out" stands of leafy spurge not in a growing crop, but two or three years are required to give appreciable control. Spring and summer applications are more effective than fall treatments.

Soil sterilants can be used to eliminate small patches and should be applied between July 1 and October 1. The borax compounds are the most effective chemicals of this group and will generally give complete elimination when applied at the rate of 5 to 6 pounds of boron trioxide per square rod (800 to 100 pounds per acre). Similar rates of sodium chlorate or ammonium sulfamate or chlorate-borate mixtures are also often effective. Seedlings that appear on patches that have been killed with soil sterilants can be eliminated with 2,4-D.

Large areas of leafy spurge can be controlled by pasturing with sheep. No harmful effects are produced on the sheep. The degree of control is dependent on the intensity of grazing that the grass will stand. Sheep should be turned into the pasture when spurge plants are 6 to 8 inches tall and good pasture management practices should be followed.

Canada Thistle (Cirsium arvense) and Perennial Sow Thistle (Sonchus arvensis)

At least two applications of 2,4-D each year over a period of two or more years are generally necessary to eradicate Canada Thistle and Perennial Sow Thistle. The first application each year should be made at the bud stage, and the later treatments in the early fall when the resprouting thistles are in the rosette stage. Rates over 1 pound per acre tend to be less effective than lower rates. Applications of 1/8 to ¼ pounds per acre repeated 2 to 6 days apart to give a total application of ½ to 1 pound are promising. Good control has been obtained by treating infested areas with 2,4-D and subjecting the area to intensive cultivation as soon as new growth appears. In some regions, Canada Thistle and Perennial Sow Thistle can be eradicated or controlled by systems of cropping and fallow adapted to local conditions in the area. Sodium Chlorate gives good control at 4 to 5 pounds per square rod (650 to 800 pounds per acre).

Hoary Cresses (Cardaria spp.)

Under semi-arid conditions summer fallowing every second year has kept the hoary cresses in check sufficiently to permit the growing of a crop in the intervening year. Seeding of infested areas to grass has resulted in great reduction in vigor, especially when applications of 2,4-D have been made.

These species have responded somewhat to applications of 2,4-D at 1 pound or more per acre in the bud or fall rosette stages. Repeated applications are required for eradication. Applications of ½ pound have been effective in reducing top growth in crops. Sodium chlorate at 5 to 6 pounds per square rod (800 to 1000 pounds per acre) has been used successfully in eradicating small patches.

Toadflax (Linaria vulgaris)

Intensive tillage (at least eight operations) during the summer fallow year has permitted the growing of one crop in northern areas. 2,4-D ester at 2 pounds or more per acre, when applied to infestations seeded to grass, is effective in reducing vigor of the weed.

Sodium chlorate at 5 to 6 pounds per square rod (800 to 1000 pounds per acre) is effective in eradicating patches of the weed when the application is repeated at least once.

Russian Knapweed (Centaurea repens)

Extensive tillage during a year of fallow only reduces the vigor of the weed slightly. 2,4-D ester at 1 pound or more per acre, when applied to infestations seeded to grass, is effective in reducing vigor of the weed. Patch treatment with sodium chlorate is satisfactory when applications are made at 5 to 6 pounds per square rod (800 to 1000 pounds per acre) and are repeated.

Soil Sterilants

CMU is suggested as an effective soil sterilant for non-crop land only, the rate necessary to be used depending on the plant to be eradicated and the soil type (less is needed on sandy soils than on clay soils).

Water Weeds and Cattails

Control of floating and submersed weeds in lakes and streams is a difficult task and only a limited amount of research on these problems appears to have been done in the North Central region. Multiple use of public waters has led, in most states, to rigid laws with respect to the addition of chemicals to water and permits are required for experimental as well as commercial applications of herbicides. The requirements are not uniform in all states, therefore it is not feasible for the NCWCC to make recommendations for use in public waters.

Cattails, in areas that are not a part of the public domain, can be sprayed with 2,4-D. A rate of 5 pounds per acre, applied just before flowering, will give reasonable seasonal control. Repeat applications for two or more seasons will be needed.

When Cattails occur in locations where the rootstocks are not covered with water, CMU at the rate of 40 pounds per acre will kill the plants.

CONTROL OF WOODY PLANTS

Both 2,4-D and 2,4,5-T have a definite place in woody plant control. Foliage sprays of 2,4-D will kill some plants not killed by 2,4,5-T and vice versa. Therefore, for general foliage spraying of mixed brush populations, mixtures of 2,4-D and 2,4,5-T are recommended. 2,4,5-T is especially effective in killing blackberries, mesquite, osage orange, poison ivy and numerous hardwoods not killed by 2,4-D. For most species and methods of treatment repeated applications are necessary. The recommendations of qualified experiment stations should be followed.

Foliage Sprays- Woody plants sensitive to either 2,4-D or 2,4,5-T may be treated with wetting foliage sprays containing at least 2 pounds of acid per hundred gallons of diluent. For the more tolerant species higher concentrations should be used. Ester formulations are recommended for most situations. To reduce hazards to sensitive crops low volatile ester formulations are recommended. Under most conditions the use of water rather than oil is preferable as a diluent. Ammonium sulfamate applied at concentrations of ¼ to 1 pound per gallon of water are also effective as foliage sprays.

Aerial spraying of post oak and blackjack osk brushland to obtain grass production requires 2 pounds of the low volatile esters of 2,4,5-T in 5 gallons of 4:1 water-oil emulsions per acre for initial treatment. Additional treatments of 1 pound per acre the second and third years will generally

be necessary to develop maximum pasturage.

Cut Surface Treatments - Many species of woody plants may also be killed by applying the above chemicals to freshly cut surfaces of frills and cups in standing trees. This type of treatment may be applied at any time of the year. Some shrubs and trees tolerant of foliage sprays may be killed by this method. 2,4,5-T esters in oil solutions at concentrations of 8 to 16 pounds of acid per hundred gallons applied to wet to the point of run-off have been effective on many species. Similar applications of 2,4-D esters have also been effective on such species as cottonwood, willow and hawthorn.

Ammonium sulfamate applied as a dry salt or as a concentrated water solution (6 to 9 pounds per gallon of water) is effective in preventing sprouting of most species of woody plants. The addition of some sticker or spreader to water solutions may be necessary.

Basal Bark Sprays - Basal stem and ground line treatments of standing trees and stumps offer promise as good control measures. Concentrations ranging from 8 to 16 pounds of acid per hundred gallons of 2,4,5-T esters in oil are recommended for most species. In some species such as buckbrush 2,4-D esters are preferred. The entire basal area at the ground line completely encircling the plant should be wetted to a point of runoff. Tree stumps should be sprayed completely with emphasis on the ground line. For shrubs this might involve the entire stem and in some species with rhizomes the ground area surrounding the plant.

Soil Treatment - Sodium chlorate, sodium chloride, CMU and borax formulations are recommended as soil treatments for control of woody plants where these herbicides are adapted. These chemicals are especially useful for spot treatment when spraying with growth regulator species is not feasible. Sodium chlorate is useful for small patches of brush not sensitive to other herbicides and where soil sterility and fire hazards are not problems. Borax is especially adapted for soil sterilization to climinate brush that constitutes a fire hazard. For the special situations under which these chemicals would be used local recommendations should be followed.

CONTROL OF WEEDS IN FIELD CROPS

Spring Sown Grain

The growing period of these small grains can be divided into at least five developmental subperiods, each responding in a different way to 2,4-D. In barley these are (1) a highly susceptible seedling period extending from emergence through the one-leaf stage when reaction to 2,4-D is expressed in the form of tubular or onion like leaves, (2) another susceptible period extending from the 2-leaf to the 5-leaf expanded stage, (3) a relatively tolerant period, between the 5-leaf and early boot stages, (4) a highly susceptible period between the early boot and fully headed stages, (5) a highly resistant period between the milk stage and full maturity. Wheat follows the same general pattern. These developmental periods are not so well defined in oats as this crop appears to be more susceptible at all stages.

Applications for weed control in barley and wheat should be made only during the third period (5th leaf to just prior to early boot stage). Oats should preferably be treated during the latter part of this period. On account of the narrow margin of safety in oats the further precaustion should be taken of applying only lighter dosages. The rate of application for any of these crops should not exceed ¼ to ⅓ pound acid equivalent per acre. Where esters are used the lower limit of the range should be regarded as near maximum.

If there is occasion for pre-harvest applications, as much as one pound acid equivalent may be applied at any time after the early milk stage without appreciable injury to the crop.

There are varietal differences in barley and oats, but since varieties differ in their adaptability and mode of growth between one soil or climatic zone and another, it does not appear practical to refine general recommendations to cover differences in varietal response.

Fall Sown Wheat

Winter wheat may be treated with 2,4-D in dosages sufficient to control most annual broad-leaved weeds without injury to the crop if applied in the spring from the fully tillered to the early boot stage. From ¼ to 1/3 pound of acid equivalent to the acre as an ester or up to 2/3 pound as an amine or sodium salt are suggested dosages. Similar applications made in the fall usually result in damage to the crop, and are not recommended. Pre-harvest treatment when the wheat is in the milk to hard dough stage should be looked upon as an emergency measure to be used only when weeds threaten to interfere seriously with harvesting. A dosage of 1 pound to the acre is required at this stage, and may result in damage to the crop. Weed control at this stage is often not satisfactory.

Flax

Cultural Practices - Weeds are generally more of a problem in flax than in small grain, therefore, growers should attempt to sow flax on relatively clean land. Early after-harvest tillage of small grain stubble to control perennial weeds, prevent weed seed production, and stimulate annual weed seed germination in late summer and fall is a recommended method of preparing land for flax the following year except where after-harvest tillage results in serious wind erosion. Preventing weed seed production in corn, soybeans, and other cultivated crops, followed by surface tillage in preparing the seedbed for flax is a desirable weed control practice. Delayed sowing of flax, although sometimes detrimental to flax, to permit spring tillage for wild oat control has been successful in some areas. For delayed sowing, early-maturing varieties such as Sheyenne or Marine are generally recommended.

Herbicides for Flax - Flax should be sprayed with MCP or 2,4-D as soon as there is sufficient emergence of susceptible weeds to make spraying practical. Spraying may reduce yields of seed and straw unless weed competition is reduced sufficiently to offset injury from spraying. Flax is more tolerant of MCP than of 2,4-D.

Use 2 to 3 ounces per acre of MCP or 2,4-D in amine formulations for susceptible weeds like wild mustard. Use 4 ounces for lamb's quarters, pigweed, stinkweed, cocklebur, marsh elder, and ragweed. For moderately resistant weeds, spot spraying at heavier rates may be necessary.

TCA at 5 pounds (acid equivalent) per acre will kill green foxtail, yellow foxtail, and barnyard grass in young flax. The flax should be at least 2 inches tall and the weeds less than 2 inches tall for best results. TCA can be applied in mixture with 2,4-D or MCP to kill susceptible grass weeds and susceptible non-grass weeds with one application.

Corn

Spraying with 2,4-D can be used to reduce the number of cultivations needed and to control some weeds in the row or hill. It should not be expected to replace cultivation because weeds not controlled by 2,4-D will be given an opportunity to develop. Cultivation is needed regardless of weeds on some soil types.

Post-emergence spraying should be as early as possible to control weeds. However, there is a stage just after the leaves unfold when corn can be readily injured. This stage may last for a week or possibly a little more. If necessary to spray at any time when the corn is large enough to put the spray under the top leaves by means of dropped nozzles, this should be done unless the weeds are taller than the corn. The spray must strike the tops of the weeds to be most effective. A rate of ¼ to ½ pound acid equivalent per acre is satisfactory using esters at lower rates than amines. Up to 1 pound may be used for resistant weeds, with probably injury to the corn.

Some injury to corn is to be expected at any time. Brittleness and bending or breakage is most serious and becomes increasingly common following over-all sprays as the corn gets taller. A storm or cultivation immediately after treatment may cause severe loss. Hybrids and varieties vary in their susceptibility to 2,4-D but differences are not important at rates below ½ pound per acre. Inbred lines vary more widely and single-cross seed fields should not be sprayed except in an emergency, or on inbreds of proven tolerance and then at minimum rates.

Pre-emergence - In most of the area pre-emergence treatments with 2,4-D will control annual grasses and some tolerant broad-leaved weeds such as purslane, which are not controlled well by post-emergence sprays. On loam soils and those of finer texture, pre-emergence use of 2,4-D is satisfactory if applied before emergence at rates of 1 to 2 pounds per acre. Treatment after emergence but before leaves unfold (coleoptile emerged) has been relatively safe. Isopropyl and butyl ester formulations are less hazardous to the corn than amine salt formulations. Dry weather after pre-emergence treatments may make them ineffective and excessive rain creates a hazard to the corn. One pound per acre may not control all weeds but is often more economical, considering cost of materials. Soils high in organic matter will require larger dosages than soils low in organic matter. Pre-emergence applications are not safe on sandy soils. An application of 2,4-D at pre-emergence rates on the soil and bases of the corn stalks only, just after the last cultivation may prevent the emergence of weeds which otherwise might interfere with harvest. Bending of the stalks at the lowest nodes may follow this treatment.

Sorghum

The use of 2,4-D for weed control in sorghums is recommended only when the weeds cannot be controlled by cultivation. 2,4-D applications under some conditions may cause severe injury. Injury is characterized by late maturity, dwarfing of the plant, and possibly death of young plants. Spraying during the bloom stage may cause sterility. The most common injury is brace root malformation which may lower yields. It is recognized that some varieties of sorghum are more resistant to 2,4-D than are others. When 2,4-D is used on sorghums the minimum dosage for weed control should be used. Amine and sodium salts of 2,4-D cause less injury to sorghums than ester formulations when applied at equivalent rates.

Soybeans and Peas

There are several cultural practices that are useful in controlling weeds in soybeans. Delayed planting combined with early seedbed preparations and frequent cultivation to kill weeds until the planting date are successful in reducing the weed hazard. Cultivation of soybeans in rows may reduce the weed population as compared to solid seeded beans.

Chemical weed control in soybeans has not been fully dependable. There are no post-emergence sprays recommended for soybeans but pre-emergence treatments offer possibilities. Dinitro-o-sec-butyl phenol at 4 to 8 pounds per acre has given the most consistent results as a pre-emergence herbicide for soybeans.

Weed control in canning peas is usually accomplished by thorough seed bed preparation prior to planting. Annual broad-leaved weeds may be controlled when in the 2 to 4 leaf stage by applying from ¼ to 1 pound per acre of dinitro-o-sec-butyl phenol as the ammonium salt in from 60 to 80 gallons of water.

Sugar Beets

Recommended crop rotations and methods of cultivation suited to conditions within the particular sugar beet growing area are the principal means of weed control.

Where annual grasses (except for wild oats, Avena fatua) are known to be a problem the application of 5 to 7 pounds per acre of TCA, acid equivalent, just before the emergence of the beets is recommended.

If weather makes it impossible to apply the spray before emergence of the crop, it is best to wait ten days. TCA at the above rates may then be used to control annual grasses. Some beets will be stunted. This should be considered an emergency treatment only.

Selective control of certain broad-leaved weeds may be obtained by the application of sodium chloride (Na cl). From 200 to 300 pounds per acre in 100 to 200 gallons of water, applied when the beets have 2 to 4 true leaves is required. This treatment is not effective on lamb's quarters and purslane. Recommendations for the particular beet growing area should be followed for all above methods.

Forage Legumes

Seedling stands of ladino clover, alsike clover, red clover, alfalfa and lespedeza, growing in flax or small grain may be sprayed with the sodium or amine salts of 2,4-D or MCP at rates up to and including ¼ pound acid equivalent, per acre for the control of many broad-leaved annual weeds. Alfalfa is generally less tolerant of 2,4-D and MCP than ladino, alsike, and red clovers and some loss of stand can be expected. Applications made when the small grain is 8 to 10 inches high usually result in less injury to legumes than applications made earlier. Sweet clover will not tolerate either 2,4-D of MCP applications. The dinitro sprays also may be used on these legumes, including sweet clover, for the control of small broad-leaved annual weeds, but more water is required and results are more dependent upon the weather. The ammonium salt of DNBP at rates of ¼ to 1 pound in 60 to 80 gallons of water per acre is suggested. With high temperatures or wet plants, use lower amounts of DNBP. TCA sodium salt, at 5 to 7 pounds acid equivalent per acre may be used to control foxtails (Setaria spp.), barnyard grass, and witch grass in seedling stands of alfalfa and sweet clover, but cannot be used when wheat, oats or barley is used as a companion crop.

Established stands of alsike, ladino, and red clovers may be sprayed with the 2,4-D, MCP and dinitro products listed above at the rates mentioned when the top growth of the legume is nearly dormant or immediately following harvest. MCP and 2,4-D will usually reduce vigor of the legume, at least temporarily. Established stands of alfalfa and sweet clover may be sprayed at the same dates with 5 to 7 pounds acid equivalent of TCA for control of foxtails (Setaria spp.), barnyard grass, and witch grass. Red clover and alsike clover are too susceptible to TCA to be sprayed.

Cultural practices that have merit for weed control in legumes in most areas of the region are:

1. The removal of heavy stubble and weeds by mowing and raking is helpful in maintaining legume stands, when sown with a grain crop, except where snow cover is dependent upon stubble.

2. Annual broad-leaved weeds in seedling alfalfa, red clover, alsike clover, and ladino clover, sown alone, may be controlled by mowing. Sweet clover will not tolerate close mowing.

3. Perennial weeds in legume seed fields may be controlled, at least to a limited extent, by patch mowing or spraying.

4. The use of a weedy first crop legume as ensilage is an effective means of removing many weed seeds from the fields.

Other practices are effective in localized areas and local authorities should be contacted for recommendations for each area.

Pasture and Range Grasses

Good management and controlled grazing are most important in any attempt at weed control in pasture land.

In very weedy pastures where good perennial grasses are thin, reseeding is probably the most important improvement practice. To be successful, a good firm seedbed should be prepared for any reseeding. Protect new seedlings from grazing until established and graze moderately thereafter. Plowing and seeding to adapted grass where practicable, will almost eliminate many of the perennial pasture species. This practice supplemented by 2,4-D treatment has given by far better control of all weedy species than either 2,4-D or mowing treatments in one reported experiment.

Mowing has been the recommended practice for controlling many kinds of weeds if done at the right time for 2, 3, or 4 years. In general, mow such herbaceous weeds as ironweed when in bud to bloom stage.

Spraying with 2,4-D or 2,4,5-T gives better control of more kinds of weeds by a single application than is obtained by a single mowing treatment. Spraying during active growing condition of the weeds gives best result. Repeated treatment for two or more years is usually necessary. Increased production of desirable forage and improvement in grass stands following treatment has been reported. In general, these materials may be used at rates necessary for weed or brush control without appreciable injury to the grasses.

Seedlings of perennial grasses may be advantageously treated with 2,4-D if the broadleaved weeds are a problem and if the land is not heavily infested with seeds of the weedy annual grasses. Rates up to ¼ pound ester per acre may be used after the grass seedlings have reached the 2- to 4-leaf stage of growth.

CONTROL OF WEEDS IN HORTICULTURAL CROPS

By the wise use of chemicals, it is possible to greatly reduce the cost of weeding many horticultural crops and to save some crops when wet weather makes it impossible to cultivate. However, chemical weed control must not be considered as a substitute for all cultivation but rather should be used to supplement standard cultural practices. There are many herbicidal treatments in addition to those listed here that may be valuable in certain localities. Only those that are of regional interest have been included in these recommendations. For other possible treatments local authorities should be consulted.

Rates of application listed for 2,4-D and TCA refer to pounds of acid equivalent. All rates of application are based on over-all coverage. It is often more economical to treat only a narrow strip over the row, in which case the application should be reduced accordingly.

Vegetable Crops

Asparagus - The common practice in most areas is to disc asparagus beds in early spring to loosen the soil, destroy weeds, and to remove the old ferns. After discing and before any spears have emerged, 2,4-D may be applied at the rate of 2 pounds or SES at 4 to 6 pounds per acre as a pre-emergence spray for the control of broad-leaved weeds. If annual grasses are a problem, 5 to 10 pounds of TCA may be added to the 2,4-D spray. A more efficient kill of the weeds may be expected if a brief interval is allowed between discing and spraying in order that the germinative processes may get under way.

Following the post-harvest discing, the above rate of 2,4-D or DNBP at 6 pounds per acre may be used before any of the spears are showing. It is not known at present whether TCA may be safely used during and after the cutting season. Present evidence indicates that it is wise to apply 2,4-D only once during any season.

Spot treatments with 40 to 50 pounds of TCA per acre just after discing are recommended for control of small areas of quack grass. Such treatment will result in some injury to the crop, but may be worthwhile to prevent spread of the weed.

In established beds, after asparagus has emerged, calcium cyanamid (granular) may be used at the rate of 300 to 400 pounds per acre if weeds are small. The dust form may be used at 75 to 100 pounds per acre if weeds are small and sufficient dew is present to stick the chemical on the foliage.

The use of Stoddard solvent at 80 to 100 gallons, DNBP at 1 pound, or 2,4-D at 1 pound per acre are recommended for contact pre-emergence treatment to control weeds in asparagus seedbeds.

Beans - In most areas residual pre-emergence sprays to control weeds in the row together with cultivation between the rows has proven quite successful. A smooth well-prepared seedbed is of inestimable value where pre-emergence sprays are used.

Six to 9 pounds of DNBP or 15 to 25 pounds of sodium PCP per acre of actual sprayed area will control annual weeds for a considerable period. The higher rates should be used where sprays are applied very soon after planting. When sprays are delayed until shortly before bean emergence, at which time many weeds may have emerged, the lower rates may be used with equal effectiveness. Where very serious infestations of annual grasses threaten, it may be necessary to apply in excess of the highest rate suggested above. Optimum concentrations of the above chemicals which may be used on various

soil types without injury to the crop must be determined by preliminary field trials.

Beets - Beets grown on muck soils are consistently threatened with heavy broadleaved weed populations during the vital period when the small crop plant is becoming established in the soil. On upland soils, annual grasses are often the major problem. The destruction of two or three crops of weeds by working the soil repeatedly before planting has given some measure of help for the early stages.

For annual grasses, a residual pre-emergence spray of 8 to 10 pounds per acre of TCA has provided excellent control. For best results the land should be well prepared by the removal of as many lumps and clods as possible. There appears to be some advantage in the control of grasses and a few small broad-leaved weeds if the spray is applied three to four days after planting.

If weather makes it impossible to apply the spray before emergence of the crop, it is best to wait ten days. Ten pounds of TCA may then be used to control grasses only. Some beets will be stunted. This should be considered an emergency treatment only.

Cabbage, Cauliflower and other Vegetables of the Genus Brassica - When any of these crops are direct-seeded a pre-emergence spray of 5 to 10 pounds per acre of TCA may be used to control annual grasses.

Carrots, Celery, Dill, Parsnips, and Parsley - Small annual weeds may be controlled on muck and upland soils with applications of Stoddard solvent at the rate of 80 to 100 gallons per acre if the entire area is sprayed. The quantity may be reduced substantially if only a narrow band over the row is treated. The sprays should be applied when most of the first crop of weeds has emerged but before any of them are more than two inches tall.

Maximum effectiveness may be obtained, and in some instances with lower rates, by applying the chemical at night when air movements are down and the relative humidity is higher. Early evening applications before the dew has formed may prove most satisfactory in those areas where exceptionally heavy dews may cause excessive run-off of the chemical later at night.

Carrots and parsnips should not be sprayed after the tap root is more than one-fourth inch in diameter or after five or more leaves are present. Stoddard solvent may be applied to celery only in the seed-bed.

Onions - For the control of weeds that have emerged before the onions, Stoddard Solvent at 40 to 80 gallons per acre, potassium cyanate at 16 to 20 pounds per acre or 3 to 5 per cent sulfuric acid at 100 gallons per acre can be used as a pre-emergence spray.

For control of weeds in onions in the "loop" stage or after the first true leaf is at least two to 3 inches long, post-emergence sprays of 2 to 3 per cent sulfuric acid at the rate of 100 gallons per acre, or potasdium cyanate at 12 to 16 pounds in 50 to 100 gallons of water per acre will control many small annual weeds. Purslane is controlled only in the cotyledon stage and lamb's quarters and grasses are usually not killed.

For the control of weeds in older onions which are bulbing and which have been "laid by", the use of basal sprays of herbicides to control late germinating weeds such as purslane is recommended. Potassium cyanate at 16 to 24 pounds per acre, 3 to 5 per cent sulfuric acid at 100 gallons per acre and DNBP at 1 to 1½ pounds per acre in 50 to 100 gallons of water are effective if applied when weeds are small. Such sprays should be applied so as to avoid hitting the tops of the onion plants either by using shields over the spray nozzles or over the onion row, or by the use of drop nozzles.

Potatoes - While blind cultivation is generally preferred, to control weeds in wet weather chemical treatments may be valuable. 2,4-D at 1½ to 2 pounds, DNBP at 4 to 6 pounds and sodium PCP at 10 to 20 pounds per acre have all given good results when applied 2 to 5 days before emergence. Where annual grasses are a problem TCA at 8 to 10 pounds per acre may be used as a pre-emergence spray. Local recommendations should be followed as regards differences in varietal susceptibility when 2,4-D is used.

Sweet corn - 2,4-D can be used in sweet corn as recommended for field corn. Pre-emergence treatments of DNBP at 6 to 8 pounds or sodium PCP at 15 to 20 pounds per acre can also be used.

Direct-seeded tomatoes - Where a large number of weeds come up before the tomatoes, Stoddard solvent may be applied at 50 gallons per acre about 2 days before the tomatoes start to emerge. Where annual grasses make up most of the weed population, a pre-emergence treatment of TCA at 3 to 4 pounds per acre two days before emergence has given good results.

Vine Crops - Weeds in cucumbers, muskmelons and watermelons have successfully been controlled with N-1 naphthyl phthalamic acid. It may be applied as a pre-emergence treatment immediately after planting these crops at from 2 to 4 pounds per acre on sandy soils or 4 to 8 pounds on heavier soils. It can also be used as a post-emergence spray where these crops are grown from transplants. In this case the application should not exceed 4 pounds per acre.

This herbicide has usually given equally good results on pumpkins and squash but there have been occasional reports of injury to certain varieties.

Seedbeds and plantbeds - Weeds can be controlled in seedbeds and plantbeds with steam sterilization or fumigation with methyl bromide.

Waste places - Weeds along drainage ditches and fence rows, around buildings, under irrigation lines, and other waste places can be effectively controlled with oils, DNBP, PCP and TCA.

Fruits and Ornamentals

Apples - Usually the worst pests in the orchard are poison ivy and brambles, and perennial weeds such as bindweed and Nightshade spp. Poison ivy can be controlled fairly successfully with Ammonium Sulfamate applied as a wetting spray of 1 pound per gallon or with 2,4-D in salt form at the rate of 1½ to 2 pounds per 100 gallons. The same materials can be used on brambles and perennial weeds but they may be more difficult to eradicate than poison ivy.

Perennial weeds and woody plants are more susceptible when the topmost leaves on the new growth are reaching full size. Some regrowth may occur and it is usually necessary to make a second application later in the same season using Ammonium Sulfamate or the following season using 2,4-D or Ammonium Sulfamate.

Application of growth regulator types of herbicides during the summer near the time of fruit bud differentiation should be avoided; reduced crop or deformed fruit may result. Herbicidal sprays should be kept off the trunk and leaves of the tree. Spot spraying of poison ivy or brambles may be advisable in some cases. If herbicides are applied with a spray boom low pressure must be used to reduce spray drift.

2,4,5-T is more effective on brambles and poison ivy than 2,4-D but it is also more hazardous.

Grapes - Where weeds beneath the trellis cannot be controlled effectively by the grape hoe they can be controlled by contact herbicides such as oil emulsions fortified with DNBP or PCP. Use 10 to 20 gallons of aromatic or fuel oil plus 2 pounds of DNBP or 4 pounds of PCP per 100 gallons of spray. Use a suitable emulsifying agent and make certain the oil remains emulsified. Apply 40 to 50 gallons per acre in a strip 18 inches wide beneath the trellis. Use low pressure (50 to 75 pounds per square inch) and fan type nozzles. Keep the spray off foliage and do not spray young vines which do not have a protective coating of loose bark.

Grapes are extremely sensitive to hormonal type herbicides such as 2,4-D.

Brambles - Weeds within the plant row of brambles grown in a hedge row or linear system of planting cannot be controlled by any implement. A deep mulch of sawdust, shavings, ground corn cobs, or straw helps measurably in the control of these weeds but the cost may be prohibitive under certain conditions and moreover the mulch presents certain hazards.

Brambles are somewhat tolerant to 2,4-D and basal directed sprays of this herbicide or contact herbicides such as DNBP can be applied without serious damage to the canes and with fairly successful control of young weeds. The first application should be made early in the spring before the weeds and the new bramble shoots emerge. The second application should be delayed until the new bramble shoots are tall enough to avoid spraying the growing tips as new canes are easily injured. Sprays must be applied at a low pressure to prevent drift.

One-half to ¾ pounds of 2,4-D acid in the salt form can be used for the early spring application while later application should not exceed ½ pound. 2,4-D should not be used during the blooming stage.

DNBP can be used at 2 to 4 pounds per acre. Higher concentrations can be used in the early spring treatment and weaker concentrations while the new canes are tender. A minimum amount of the spray should contact the cane bases. DNBP must be applied while the grass and broad-leaved weeds are small to be effective.

Sodium 2,4-dichlorophenoxy ethyl sulfate (SES) has shown promise as a herbicide for use in raspberries. It can be used at the rate of 3 to 6 pounds per acre at any season. To be effective SES must be applied ahead of weed emergence.

Strawberries - In most seasons weeds in newly set strawberry fields can be controlled by mechanical cultivation up until the time that runner plants begin to set. After this time considerable hand labor is required to keep the row free of weeds. Strawberries are somewhat tolerant to hormonal type herbicides and 2,4-D and Sodium 2,4-dichlorophenoxy ethyl sulfate (SES) are the most promising herbicides for use in this crop.

Pre-planting treatments with 2,4-D (amine salt) have shown promise at the rate of 2 to 3 pounds per acre (higher rates for clay soils and soils high in organic matter and lower rates for sandy soils) where the soil is disturbed little in the planting operation. As selective foliage sprays 2,4-D may be used at the rate of approximately one pound during the period from 3 to 4 weeks after setting until late August when fruit bud differentiation begins.

Runner production may be reduced by 2,4-D application. The degree of reduction depends upon concentration, number of applications, environmental conditions, and physiological stage of plant when treated. Treatment at the time of runner initiation usually causes a marked inhibition of runners.

To be effective against grasses 2,4-D must be applied no later than the germination stage. For the control of over-wintering weeds 2,4-D at the rate of 1½ pounds per acre has given excellent control of weeds. Application, however, must be delayed until after the period of fruit bud differentiation to prevent fruit deformity.

One pound or less of 2,4-D may be used at the time of mulch removal if over-wintering weeds were not controlled in the late fall. One pound of 2,4-D per acre may be used just before the fruit begins to ripen as an emergency measure if annual broad-leaved weeds threaten to take the field. 2,4-D must not be applied during the blooming period. This material has an important place in weed control the second summer and can be used at the rates of 1½ to 2 pounds per acre.

Sodium 2,4-dichlorophenoxy ethyl sulfate (SES) is an effective herbicide only after it has been changed to an active form in the soil by the micro-organisms. Due to the nature of this material it is less injurious to the strawberry plants and is effective against weeds only in the seedling stage. This material may be used immediately after setting at the rate of 3 to 6 pounds per acre without any serious injury. Excellent weed control for three weeks or longer is usually obtained. Repeat applications may be made during the spring, summer, and fall months as needed. Runner production is reduced only slightly at these rates. It appears safe to use during the critical period of fruit bud differentiation; however further investigational work should be done with this material at this stage of growth.

Herbicides may be applied to the whole field or applied only in a band over the row. Rates of application are based on the area sprayed and the actual amount of chemical applied will be ½ or less of the per acre rate in the case of band applications.

Gladiolus - Pre-emergence treatments of 2,4-D (ester or salt) 2 pounds acid equivalent per acre, DNBP, 8 pounds per acre, and sodium 2,4-dichlorophenoxy ethyl sulfate (SES) 3 to 6 pounds per acre will control most annual broad-leaved weeds. Where annual grasses are the primary problem TCA, at 10 pounds per acre can be used. If both types of weeds are present a mixture of 2,4-D and TCA may be used.

Post-emergence treatments with 2,4-D (salt), at the rate of 1 pound per acre when the gladiolus are six inches tall or before the leaf blades open controls most of the weeds in the row. Considerable injury may result if higher concentrations of 2,4-D are used and if the plants are treated in their later stages of growth.

Recent experiments indicate that SES is less injurious than 2,4-D and can be used pre-emergence at the rate of 3 to 6 pounds per acre and post-emergence at similar rates.

Cormels grown for size increase are more subject to injury than flowering size corms.

Nursery Stock - For transplant beds and seedling beds methyl bromide and other oils fumigants may be used. Stoddard solvent or equivalent aromatic oils may be used to help control broad-leaved weeds and annual grasses in coniferous seedling and transplant beds. The rate of application varies from 25 to 75 gallons per acre depending on species and growth stage of seedlings at the time of spraying.

For coniferous transplants and deciduous stock in rows aromatic oils fortified with PCP or DNBP may

be used between the rows if applied with a hooded boom and low pressure to prevent drift. Application to the base of the plant should be avoided.

Considerable hand labor can be saved by planting lining-out stock on the square to permit cross cultivation.

TCA is recommended for use in connection with quack grass control. Soil applications heavy enough to control the quack grass can be applied the season before planting the coniferous seeds.

Juniperus spp., Picea spp., Syringea spp., Philadelphus spp., Paconia spp., and Thuja Orientalis have been found to be tolerant to foliage applications of SES. This herbicide should not be used on Oriental poppy (Papaver orientale), Redbud (Cercis canadensis), and Privet (Ligustrum amurense).

Turf

Broad-Leaved Weeds - Control of annual broad-leaved weeds in new turf can be obtained by ordinary mowing and management practices which favor the development of good turf grasses. Herbicidal sprays should not be applied until the turf is one year old.

In established turf certain perennial weeds can be controlled by applications of 2,4-D made when the weeds are in active growth. Periods of active growth, in most of the North Central Region, occur in both spring and fall. Because of less risk of injury from drift to adjacent ornamental plantings, fall applications are generally preferred. The amine salt of 2,4-D, at a concentration of 0.1 to 0.2 per-cent, acid equivalent and a volume of 1 gallon per 1000 square feet, is adequate for many species. Better results on resistant species will be obtained when 2,4-D esters are used but more damage from drift or volatization may occur.

Crabgrass - may be controlled by any of the following methods:

1. 2,4-D, Amine, at the rate of ¼ ounces per 1000 square feet, applied when first grass seedling emergence is observed.

2. Potassium Cyanate, 3 ounces per 1000 square feet, preferably when crabgrass seedlings are not more than 2 inches in height. Repeat applications at 7 to 10 day intervals may be required.

3. PMA, 0.3 ounce per 1000 square feet, as soon as crabgrass seedlings are observed. The application must be repeated at 7 to 10 day intervals until 3 to 5 applications have been made.

DESICCATION, VINE KILLING, AND PRE-HARVEST WEED CONTROL

General - The presence of weeds and green crop materials in flax, soybeans, winter wheat and small seeded legumes at harvest time frequently complicates harvest methods and results in considerable loss of seed. Commercial potato growers have found that it often is desirable to remove heavy vine growth and weeds by mechanical or chemical means in advance of digging. Based on very limited experimental work and field observations in the North Central Conference area, the following recommendations are offered:

Flax - 2 to 3 pints (1.25 to 1.87 pounds) of DNBP (phenol) with 5 to 10 gallons of diesel or fuel oil per acre applied at the normal time for swathing. Also suggested is a 40% solution of pentachlorophenol mixed 1 to 9 with fuel oil and applied at 5 gallons per acre, or 2 to 3 gallons per acre of a 5 to 10% solution of pentachlorophenol.

Results have been best when boom type ground equipment was used. Air applications have been less satisfactory but have a distinct advantage from the standpoint of avoiding mechanical injury. For air applications, 5 gallons of solution per acre is considered a minimum rate. When good harvest weather prevails the desired objectives can be obtained in 36 to 48 hours, permitting straight combining of the crop.

Soybeans - The same materials and rates that are recommended for flax are suggested. Treatment to be applied when beans are nearly mature.

Alfalfa and Clovers - Recommended treatments are DNBP (phenol) at 2 to 3 pints (1.25 to 1.87 pounds) with 5 to 10 gallons of fuel oil per acre, or PCP (phenol) at 4 to 6 pounds in 5 to 10 gallons of fuel oil. Some tests show an advantage from emulsifying the above materials in water and applying the emulsion at 25 to 50 gallons per acre. Also suggested is 1 pound of Endothal with 4 pounds of ammonium sulphate in 20 to 30 gallons of water per acre.

Potatoes - For the most part the use of a roto-beater has proven most satisfactory. If, following mechanical vine destruction adverse weather interferes with digging, annual grasses may present a problem. In such cases DNBP (phenol) at 2 to 3 pints (1.25 to 1.87 pounds) in 5 to 10 gallons of oil per acre will check the growth of weeds. The chemical treatment alone will not ordinarily be sufficient where there is a normal vine growth.

Vine killing should precede digging by about 3 weeks. Any method of forcing maturity may affect the physical characteristics of the tubers.

Winter Wheat - Pre-harvest treatment when the wheat is in the dough stage should be looked upon as an emergency measure to be used only when weeds threaten to interfere seriously with harvesting. A dosage of 1 pound of 2,4-D acid per acre is required at this stage and may result in damage to the crop. Another suggestion is 2 to 3 pints (1.25 to 1.87 pounds) of DNBP (phenol) with 5 gallons of diesel oil. An effort should be made to apply the chemicals 10 days to 2 weeks in advance of harvest. Weed control has not always been satisfactory with these treatments.

MECHANICAL CONSIDERATIONS

Mechanical considerations of a good program of weed control include the use of a proper crop rotation, clean seed, tillage equipment, chemical spraying equipment and harvesting equipment. There is no one factor of the above group which will give good weed control when used exclusively by itself with no regard to the other. It is to be recommended that all of these factors be included if possible in setting up the weed control program.

Crop rotation - It is very important that each farm have an individual crop rotation conforming to its soil, climatic terrain and economic requirements. This rotation is very helpful as a weed control measure in providing the proper competitive crop and in making the opportunity available for the proper timing of the other factors.

Clean seed - It is highly recommended that all seed used be as free of weed seed as possible. The absence of weed seed in the planting will be reflected in less work later on for the tillage and chemical practices and more important is the effect of making certain of not introducing new weed species.

Tillage equipment - The effectiveness of tillage operations is dependent upon the timing, speed and adjustments of the implement. It is recommended that all three variables be given careful consideration

based on the soil type, conditions and crop.

The adjustment of the implement is especially important in the use of the cultivator in that it should give as much weed control as possible within the crop row and yet should avoid injury to the plant or pruning of the roots. It is recommended that floor line diagrams be used for making proper spacing and depth adjustments of tillage implements.

Sprayers - The farm weed sprayer is a rather new addition to the line of weed control machinery and in their acquisition the same careful consideration should be given to their service and repair as is given the other implements. For this reason it is recommended that dealings be made with only reputable dealers and manufacturers.

Some of the desirable features of a good weed sprayer are as follows:

Tank: The tank should be strong enough to withstand the pressure of the fluid splashing around inside and should be of a size compatible with the sprayer size and operations under consideration. It should also be of a material which is as corrosion resistant as possible. It should also be equipped with an opening which will allow for cleaning the inside when necessary. Provisions should be included for draining.

Suction Strainer: This strainer should be fine enough to remove as much foreign material from the solution as possible and yet not throttle the suction action of the pump. Inasmuch as this requires a compromise, special emphasis should be put on precautionary measures as the time the tank is being filled.

Pump: The pump should be of sufficient capacity and quality to maintain adequate working pressure and flow to meet the particular conditions set by the spraying operation. An important point to consider is maintaining the pressure at reduced speeds of power take-off pumps when used with some tractors where the choice of gear and speed will require operation at less than full throttle.

Regulating valve and pressure gauge: These two items which are closely associated should be within easy reach and sight of the operator. The marked increments of the gauge should be considered with respect to the spraying operation and are recommended as 2 pounds for low pressure weed spraying.

Boom: Booms should be of adequate strength and be well supported to prevent breakage. They should be of large enough diameter to prevent a significant pressure drop at the end nozzles and should be as corrosion resistant as possible.

Other features essential to a good sprayer are quick shut-off valve, line filter between the pump and boom, individual filters at each nozzle and some device for measuring the fluid in the tank.

Calibration: It is recommended that the sprayer be calibrated to each particular operation. The best method of calibration being the making of initial adjustments to suit the machine and job requirements, then making a trial run to determine the actual output and mixing the herbicide accordingly. This calibration should be checked frequently during the operation.

Maintenance: A strict maintenance program should be followed and should consist of normal precautions by the operator to avoid breakage and should be flushed thoroughly after each use. For winter storage it should be cleaned, dried out and the metal parts coated with oil as an aid to prevent rusting.

Harvesting equipment - It is recommended that for each piece of harvesting equipment a strict individual cleaning program be set up and adhered to before moving the machine from place to place.

RECOMMENDATIONS OF THE COMMITTEE ON TERMINOLOGY, NCWCC

December 11, 1952.

The Committee recommends the use of the terms, definitions, and abbreviations listed in this report in the preparation of abstracts, reports, and articles that have to do with weed control. The use of the recommended forms, definitions, etc. is especially desirable in the preparation of short reports in order to conserve space and to make for easier interpretation of results by project leaders and readers in general.

Trade Names and Code Numbers usually should not be used. The Research Committee has ruled that reports on materials by code number or trade name only shall not be used in preparing summaries. Some highly complex organic herbicides have been introduced under trade names. As long as these products are made by only one company, the trade marked names (always capitalized) may be used in the body of an article or abstract. The first time such a product is mentioned in a research report, the full chemical name should be given, followed by the trade name in parentheses.

Chemical Names and Designations. Chemical symbols should not be combined with alphabetical abbreviations in designating compounds, for instance, the sodium salt of TCA should not be stated as NaTCA. In the list which follows, the chemical name is given in (a) followed in (b) by common names of basic compounds (c) common derivatives of basic compound.

Rates and concentrations for materials listed in items, 1, 2, 3, and 4 should be stated as the acid equivalent.

1. (a) 2,4-dichlorophenoxyacetic acid
   (b) 2,4-D
   (c) 2,4-D, salt (indicate which)
   2,4-D, ester (indicate which)

2. (a) 2,4,5-trichlorophenoxyacetic acid
   (b) 2,4,5-T
   (c) 2,4,5-T salt (indicate which)
   2,4,5-T, ester (indicate which)

3. (a) 2-methyl-4-chlorophenoxyacetic acid
   (b) MCP
   (c) MCP, salt (state which)
   MCP, ester (state which)

4. (a) trichloroacetic acid
   (b) TCA
   (c) TCA, salt (state which)

Rates and concentrations for materials listed in items 5,6,7,8, and 9 should be stated as the phenol equivalent.

5. (a) pentachlorophenol
   (b) PCP
   (c) PCP, sodium salt (rates have usually been stated in terms of the salt)

6. (a) 4,6-dinitro-o-cresol
   (b) DNC
   (c) DNC, salt (state which)

7. (a) 4,6-dinitro-o-sec-butylphenol
   (b) DNBP
   (c) DNBP, salt (state which)

8. (a) 4,6-dinitro-o-sec-amylphenol
   (b) DNAP
   (c) DNAP, salt (state which)

9. (a) N-1-naphthyl phthalamic acid
   (b) NP
   (c) NP, salt (state which)

Rates and concentrations for all the following materials should be stated as pounds or ounces of active ingredient.

10. (a) phenyl mercuric acetate
    (b) PMA

11. (a) isopropyl-N-phenylcarbamate
    (b) IPC

12. (a) isopropyl-N-(3-chlorophenyl) carbamate
    (b) CIPC

13. (a) 3-p-chlorophenyl-1-1-dimethylurea
    (b) CMU

14. (a) 3,6-endoxohexahydrophthallic acid
    (b) endothal

15. (a) sodium 2,4-dichlorophenoxethyl sulfate
    (b) SES

16. (a) potassium cyanate
    (b) KOCN

17. (a) maleic hydrazide
    (b) MH

All other compounds should be listed by their full chemical names.

DEFINITIONS

1. Pre-emergence applications are those made after crop is planted but before it emerges and are of two kinds: (1) contact pre-emergence - an application made after weed emergence and (2) residual pre-emergence which kills weeds as the seed germinates or as they emerge either before or after the crop has emerged.

2. Soil sterilant. A material which renders the soil incapable of supporting plant growth. Sterilization may be temporary or relatively permanent.

3. Contact herbicide. A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.

4. Low volatility, as applied to herbicides such as 2,4-D, 2,4,5-T and other similar compounds, is a relative term. Differences in volatility are real and important, but so far, can be determined only by biological tests.

5. Low volatile esters. The esters of 2,4-D, 2,4,5-T and other similar herbicidal compounds that have low volatility should not be designated as non-volatile esters.

6. Spray drift. The movement of airborne spray particles from the spray nozzle outside. The intended contact area.

7. Vapor drift. The movement of herbicidal vapors from the area of application to adjacent areas.

8. Rate and dosage. These terms are synonomous. "Rate" is the preferred term. Rate refers to the amount of active material (such as 2,4-D acid equivalent) applied to a unit area(such as one acre) regardless of percentage of chemical in the carrier.

9. Concentration. Refers to amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds per unit volume of diluent.

10. Herbicide. A chemical known to be toxic to some chlorophyll bearing plants.

11. Dormant treatments of deciduous woody plants refer to applications of herbicides made during the period after leaf-fall, or death of leaves, and before bud-break.

12. Basal treatment. A basal treatment is an application to the stems of plants at and just above the ground line.

13. Alphabetical designations for chemical compounds should be capital letters (upper case) without spacing or periods; for example MCP, PCP.

ABBREVIATIONS

The use of the following abbreviations is recommended and, unless otherwise indicated, should be small letters (lower case) without spacing or periods.

acid equiv. per 100 gal.	ahg	parts per million	ppm.
acre	A	pint or pints	pt
bushel or bushels	bu	pound or pounds	lb
diameter	diam	pounds per sq. in	psi
foot or feet	ft	quart or quarts	qt
feet per minute	fpm	rate per acre	gal/A, oz/A, lt/A, bu/A
gallon or gallons	gal	revolutions per minute	rpm
inch or inches	in	square	sq
miles per hour	mph	weight	wt

RESOLUTION

WHEREAS, the NCWCC and WCWCC has greatly enjoyed the excellent facilities provided for holding this Joint Conference,

NOW, THEREFORE BE IT RESOLVED that we express our thanks to the Province of Manitoba, the City of Winnipeg, the Royal Alexandra Hotel and especially to Mr. H.E. Wood and his associates on the General Arrangements Committee who were H.A. Craig, H.J. Mather, F.J. Greaney, D.M. McLean, F.C. Birt, D.D. Fraser, W.H. Silversides, J. Howden, W.D. Watson and Mrs. D.M. McLean;

To Line Elevators Farm Service for printing the Conference program; likewise to Manitoba Pool Elevators for the banquet souvenir menu; to the T. Eaton Co. Ltd. for tendering visiting ladies a luncheon.

To the Hon. Mr. Justice Freedman for the extremely interesting and appropriate address, so ably delivered,

And to many other individuals and organizations who have helped to make this Conference a success, we wish to express our appreciation.

WHEREAS to be effective the findings of weed specialists must reach farm operators and

WHEREAS press and radio coverage assists in achieving this objective

NOW, THEREFORE BE IT RESOLVED that the NCWCC and the WCWCC express their appreciation for the aid of the Radio and Press representatives in the wide dissemination of recent findings in Weed Research, and particularly for the excellent publicity given the Conference.

Carried Unaminously
December 11th, 1952.

Resolutions Committee

F.W. Slife - Chairman
W.D. Widdifield
T.V. Beck

APPENDED

From The Western Canadian Weed Control Conference

THE USE IN WESTERN CANADA DURING 1952 OF 2,4-D TO CONTROL WEEDS IN CROPS

H.E. Wood, Manitoba Department of Agriculture.

Since 1947 when 2,4-D came into use for the control of weeds in grain crops throughout the Prairie Provinces the writer has undertaken an annual survey to determine the acreage treated. This survey has been made possible by the co-operation of formulators and those merchandising herbicides. The survey, recently completed, indicates an estimated 13, 497,00 acres were treated in 1952. A breakdown of data follows:

Treated by Provinces (1952)

	Acres Treated	Percent Sprayed	Percent Dusted	Aircraft Applied %	Percent Ester
Manitoba	1,735,000	91.4	8.6	Nil	93.3
Saskatchewan	8,457,000	92.9	7.1	2.4	96.4
Alberta	3,259,000	83.2	16.8	1.2	98.0
British Columbia	46,000	97.8	2.2	?	84.8

Details of Application:

As Spray	12,197,000 acres	- 90.4%
As Dust	1,300,000 acres	- 9.6%
As Ester	13,005,000 acres	- 96.4%
By Ground Equipment	13,245,000 acres	- 98.2%
By Aircraft	242,000 acres	- 1.8%

Acres Treated Previous Years: (3 Prairie Provinces)

1952 - 13,497,000 acres	1949 - 8,200,000 acres
1951 - 11,326,000 acres	1948 - 4,000,000 acres
1950 - 13,566,000 acres	1947 - 500,000 acres

REPORT OF THE HERBICIDE COMMITTEE

Recommended rates of applying 2,4-D and MCP as spray, 1/ on Cereals, Flax and Legumes as a Post Emergence treatment to Control Weeds.

		Ounces Acid equivalent per Acre		
		Annual Weeds		Perennial Weeds
Crop	Formulation	Susceptible	Intermediate	Top Growth Control
2,4-D				
Wheat, barley, rye, corn	ester	3 to 5	4 to 8	4 to 8
	amine	4 to 8	5 to 10	6 to 12
Oats	ester	2 to 4	3 to 6	4 to 6
	amine	4 to 8	5 to 10	6 to 12
Flax	ester	2 to 4	3 to 6	4 to 6
	amine	3 to 6	4 to 8	4 to 8
MCP				
Wheat, barley, oats, rye, corn	ester	3 to 6	5 to 8	6 to 10
	amine	4 to 8	5 to 10	6 to 12
Flax	ester or amine	3 to 6	4 to 8	4 to 8
	sodium salt	4 to 8	5 to 10	5 to 10
Alfalfa and clover (except sweet clover) early growth stages	sodium salt	2 to 4	-	-
Peas	sodium salt	1½ to 3	2 to 4	-

1/ Where the above chemicals are applied in a dust carrier it is generally advisable to use up to one-third more acid per acre than the rate recommended in a water spray.

EXPLANATORY NOTES

Rates - The quantity of acid to use within the ranges recommended in the table will be influenced by the following factors:

Stage of Weed Growth - Annual plants are generally more susceptible when young, i.e., in the seedling or rosette stages of growth. Resistance increases with advancing maturity. Perennial plants for the most part are less susceptible than annuals. They are usually most successfully treated at the bud or very early bloom stage.

Species of Weed - There is wide variation in the response of weeds to 2,4-D and MCP (see weed classification chart).

Growing Conditions - Plants are usually more susceptible to 2,4-D and MCP under conditions that favour rapid growth.

Higher Rates - The higher rates in the table are recommended particularly under drier conditions, for weeds that are intermediate in response to the chemicals, and, for crops that are heavily infested with weeds. Under certain conditions these higher rates may cause injury to the crop but this will frequently be offset by obtaining a higher relative yield from a less weedy crop.

Spring Wheat and Barley - Should not be treated until expansion of the fourth leaf or approximately when the plants are 6 inches in height. Treatments can then be safely made until early boot stage and again from soft dough stage until maturity.

Winter Wheat and Rye - Can be treated in dosages that will control most annual and winter annual broad-leaved weeds, in the spring, from the time the crop commences growth to early boot-stage.

Oats - This crop is more sensitive to 2,4-D than wheat or barley, especially from emergence to shot-blade stage. Treatment can most safely be done from the time the plant has reached early shot-blade stage (8 to 10 inches in height) and the stem is beginning to elongate, up to early boot stage. Using moderate rates of amine (4 to 8 ounces) treatment may be made between the 3 to 6-leaf stages with little danger of serious damage.

Flax - Should be treated as soon as weed growth warrants, provided the flax has formed 3 to 4 leaves. Severe damage to flax is liable to occur if the treatment is done after the early bud stage. Flax is more tolerant to 2,4-D amine, MCP amine, and MCP ester than to 2,4-D ester. When the more resistant types of weeds are present the use of 2,4-D ester is preferable. (For the control of green foxtail see section on TCA).

Corn -- Field and Canning - Rates recommended for wheat and barley can be used safely on corn. Spraying should be done as early as possible to control susceptible annual weeds preferably when the corn plants are 6 to 8 inches tall.

Legumes - alfalfa and clover (except sweet clover) - MCP has proved less harmful than 2,4-D to alfalfa, red and alsike clovers in the seedling stage. Well developed, thick stands can be treated with reasonable safety with MCP at rates recommended in the table. It is not advisable to use the ester formulation. Treating alfalfa and clovers is not, however, recommended unless the crop is seriously weed infested.

Peas, Field and Canning - These crops can successfully be treated with MCP (sodium salt) or water soluble dinitro products when the plants are from 4 to 8 inches in length. Weed control with MCP should be restricted to the following varieties: Dashaway, Early Perfection, Lincoln, and Racemaker.

Sugar Beets - Apply TCA at rates of 5 to 10 pounds (active ingredient) as a pre-emergence treatment for annual grasses (except wild oats) using at least one gallon of water to each pound of the chemical. The same rates can be used for post-emergence treatment at 10 days to 2 weeks after emergence. Common salt at 200 pounds per acre applied in 100 to 200 gallons water as a post-emergence treatment when the beet plants have 4 true leaves can be used for the control of broad-leaved weeds but this is only recommended as an emergence measure.

Control of Biennial and Perennial Weeds in Pastures and on Waste Land - Selective herbicides can be used for weed or brush control on native grass pastures, waste land and on cultivated pastures in which legumes are not mixed with grass. Ester of 2,4-D at 1 to 2 pounds (acid equivalent per acre) is recommended for the control of many pasture weeds. More than one application may be necessary for satisfactory results. (see control of Woody brush).

Control of Woody Plants - Certain species of woody plants (see weed classification chart) can be killed, or successfully controlled by foliage sprays, over-all dormant sprays, basal bark and stump treatments. For foliage spraying 2,4-D, or when species resistant to 2,4-D are present, mixtures of 2,4-D and 2,4,5-T at rates of 2 to 4 pounds of total acid equivalent in 10 or more gallons of water per acre (sufficient to thoroughly wet foliage) should be used. Tall growth should be cut back and the re-growth sprayed the following year. Foliage spraying is best done as soon as leaves are fully expanded. For over-all dormant spraying conducted during the absence of foliage, oil at 10 to 20 gallons per acre must be substituted for water as a carrier. When a mixture of 2,4-D and 2,4,5-T is used the ratio should be 2 parts of 2,4-D to 1 part of 2,4,5-T.

For basal-bark and stump treatments the ester form of 2,4-D or of 2,4-D plus 2,4,5-T should be used in an oil carrier. Rates of 1½ pounds of total acid per 10 gallons of oil for basal bark and stump treatments are recommended. The bark at the ground line and protruding roots should be wetted to a point of runoff. In basal bark treatment apply from 3 feet down, and, in stump treatment cover the entire stump including cut surface.

USE OF OTHER CHEMICALS

Trichloroacetate (TCA) - This product will control green foxtail (Setaria) when applied at 5 to 8 pounds of acid per acre to flax when plants are 3 to 7 inches high and the foxtail not more than 2 inches in height. At least 1 gallon of water should be used to each pound of TCA. The control of broad-leaved weeds and green foxtail may be obtained by combining TCA with 2,4-D amine or MCP in a single spray mixture. TCA will effectively control couch grass when applied to established stands at 80 to 100 pounds acid per acre when the sod is undisturbed, and, 50 to 75 pounds following ploughing or other tillage. Best results are secured when treatments are done between August and October. Follow-up cultivation during the next summer can economically be used to complete the process of eradication. At heavy rates the residual effects may extend over at least a two-year period.

Sodium Chlorate Compounds - These compounds can be satisfactorily used for treating couch grass and persistent herbaceous perennials at rates of 3 to 16 pounds of active ingredient per square rod. The heavier rate or even higher may be required on alkaline soils, light soils, or, on soils high in organic matter. These compounds render the soil sterile for some years. Repeat treatment if necessary.

CMU - at rates of 20 to 80 pounds active ingredient per acre will eradicate couch grass and certain persistent herbaceous perennials but leaves the soil sterile for several years.

Selective Dinitro Compounds - Are useful for the control of weeds in crops that are relatively sensitive to 2,4-D such as alfalfa, clovers, peas and certain truck garden crops.

WEED CLASSIFICATION (Refer to 5th WCWCC Proceedings)

Suggested Changes.

Russian pigweed	- from Group 1 to Group 11.
Cocklebur	- from Group 1 to Group 11.
Dog Mustard	- from Group 1 to Group 11; remove from Group 111.
Currants, box elder and wolf willow	- from Group 111 to Group 1.
Balsam poplar	- from Group 11 to Group 1.

REPORT OF THE WEED CONTROL MACHINERY COMMITTEE

Introduction

Weed control in Western Canada depends upon a thorough cultural programme supplemented with adequate seed cleaning and the proper use of chemicals. Tillage for weed control cannot be separated from moisture and soil conservation practices or from seed bed preparation. Other phases of farm operations, such as seeding and harvesting, are also important and equipment for all of these practices should be considered.

Tillage Equipment

Research has indicated that timeliness is of paramount importance in fall, spring (pre-seeding and post-seeding) and summerfallow tillage to get weeds to germinate so that they can be destroyed. It is, therefore, recommended that timely cultivation with due consideration to germination and destruction of weeds be practised. In areas where continuous cropping is practised it is recommended that special tillage and crop management for weed control be used.

Incomplete cuts by implements frequently allow weeds to remain. It is recommended that more attention be paid to sharpening, adjusting, maintaining of e-equipment, and to the use of markers. All tillage operations must be carried out at an effective depth to give a complete cut of the tilled area. The quality of each tillage operation should be such than an even, weed-free bed of uniform depth is prepared. Tillage machinery should be operated at such speeds as to provide greatest weed control compatible with soil and water conservation.

Seeding Machinery

Since uniform seeding at the proper depth facilitates the production of a good stand of vigorous seedlings, it is recommended that special care be exercised in the selection of seeding equipment. This equipment must be selected on the basis of soil type, topography, and amount of trash normally handled. When extensive trash cover is encountered this may be reduced to the desired level by the judicious use of disc machines. New equipment is being developed for seeding through heavy trash.

Tests using heavy packers after seeding have indicated more uniform emergence and improved competition with weeds, resulting in better yields.

Equipment for Field Application of Chemicals

Desirable features of boom sprayers and boom dusters remain the same as those reported in the 1950 and 1951 proceedings of the WCWCC.

It is further recommended for field sprayers and dusters:

1. That spraying and dusting machines be subject to the provisions of the Farm Implement Acts.

2. That where trucks are being used to apply dusts or sprays a constant speed-governor is desirable to provide a uniform rate of travel.

3. That all power-take-off driven machines be provided shields to comply with the A.S.A.E. standards, and that other types of drives should be provided with shields necessary for safe operation.

4. That simple and adequate instructions for maintenance and operation with various chemicals be provided. These instructions should be in durable form and should also contain recommendations for cleaning and storage of machines.

With regard to application of chemicals it is recommended:

1. That 2,4-D be applied for control of weeds as a liquid spray or as a dust.

2. That 2,4-D be applied as a spray by boom sprayers or aircraft, and as a dust by ground dusters.

3. That with boomless type sprayers further field testing is necessary before boomless type equipment can be recommended.

4. That in the application of chemicals, precautions should be taken to minimize the possibility of damage from drift.

5. That provisions be made to protect the operator from the hazards of toxic chemicals.

Aircraft Spraying

Aircraft application of spray has been satisfactory when carried out by competent operators with chemicals that lend themselves to this type of application.

Roadside and Ditch Bank Equipment

Machines which will give adequate volume and coverage of roadside and ditch bank growth may by used.

The same safety recommendations apply to this type of equipment as those suggested for field equipment.

Harvesting Equipment

Since most of the grain is harvested by combines, the use of recleaners is recommended so that weed seeds can be collected for disposal.

While it is recognized that the combine exterior has been improved to facilitate easier cleaning, there still is a possibility of weed seed being carried by the combine from one field to another. It is recommended that for inacessible parts some auxiliary air cleaning equipment be employed. This recommendation also applies to threshing machines, grain handling, and haying equipment.

Seed Cleaning Equipment

The need for seed cleaning is evident from the results of seed drill surveys and general observation. Equipment is available that will separate seeds accurately on the basis of size, shape and density, but because of the wide range of weed seeds to be removed no single principle of separation will give satisfactory results except in isolated cases.

Minimum requirements for the farm cleaning plant include a windscreen machine in combination with a length grader, housed in a suitable building. This will do an efficient job when properly operated.

For portable units similar equipment may be used. This should be supplemented, however, with auxiliary air cleaning equipment to assist in removing all weed seeds and foreign material from the units before moving to the next location.

Well designed stationary cleaning plants, equipped with multiple seed cleaning equipment, and manned by competent operators, offer an ideal way of providing satisfactory seed cleaning service.

It is recommended that the construction of stationary plants be widely encouraged.

REPORT OF THE COMMITTEE ON TILLAGE AND CROPPING

General Recommendations for the Control of Annual, Winter-Annual and Biennial Weeds.

1. Seeding Practices

(a) Sow only sound, well cleaned seed. Crops from seed of low vitality cannot compete successfully with weed seedlings.

(b) Destroy as many weeds as possible before seeding. Pre-seeding tillage to kill weeds is particularly important where winter-annuals and biennials are abundant.

(c) Uniform seeding at the proper depth facilitates the production of a good stand of vigorous seedlings. The pre-seeding tillage should therefore be as shallow as possible to provide a seed bed of firm moist soil. Packing after seeding will hasten germination and improve stands under most conditions.

(d) Rate of seeding: seed crop at the recommended rate for the district. However, under conditions of possible heavy weed infestation, an increase in this rate of seeding will help provide more effective competition.

(e) Fertilizers, used where practical and in accordance with local recommendations, give crops the earlier, more vigorous growth needed to put them ahead of weed seedlings.

(f) Light post seeding tillage, with either the rod weeder or the harrows, will give good control of weeds in those seasons when the weed seeds have germinated before the seeded crop has sprouts more than one-half inch in length. For wild oat control harrowing just after the crop has emerged is recommended in some of the moister regions of the prairies.

2. Summerfallow Practices

(a) Light after-harvest tillage of land to be summerfallowed is a recommended practice in moister or parkland regions. In the open prairie areas it is recommended only when there are green weeds, such as Russian thistle in the stubble, which might grow and develop seeds and/or when there is a heavy growth of winter annual weeds in the fall. Blade weeders and wide-sweep cultivators seem best adapted for this type of tillage since the stubble is left more or less standing, and is therefore able to trap snow and protect the soil.

(b) The first tillage operation in the spring of the fallow year should, if possible, be made before spring seeding starts, whether the first aim of the fallow is moisture conservation or weed control. Blade and wide-sweep cultivators used in conjunction with harrows give good weed kills and help preserve the trash cover. Disc-type machines have been found to be somewhat more effective against certain weeds such as downy brome. The disc-type machines cut up the trash to a greater extent than the blade weeder or the cultivator, hence in years when the trash cover is light, disc machines should be used very sparingly. Excessive working of summerfallow is conducive to erosion, therefore tillage should only be given when weed growth warrants it.

(c) The trash cover method of fallowing has not been found to have noticeably increased the weed infestation.

(d) A combined use of tillage and herbicides in the preparation of fallow has been used successfully in southern Manitoba where field bindweed was a problem. Canada thistle, perennial sow thistle, and redroot pigweed were also effectively controlled by this method. In most areas resistant weeds and volunteer grain have largely nullified the effect of the herbicide.

(e) Partial fallow, i.e. after a crop of hay has been removed, has given satisfactory weed control in addition to breaking out a sod crop. This type of fallow can only be used to advantage in the moister regions and in British Columbia.

3. Control Weeds on Uncultivated Land

Fence lines, stack bottoms, road allowances and barnyards produce vast quantities of weed seeds which will spread to nearby land. Such areas should be cleaned up and sown to a strongly competing grass. On pastures and range lands overgrazing should be avoided to prevent weeds from becoming established.

4. Avoid Spreading Weed Seeds with Farm Machinery

Thoroughly grind feed grain containing weed seeds. Dispose of screenings preferably by burning. Do not haul them in an uncovered truck or wagon.

5. Competitive Crops

(a) Fall rye has a definite smothering effect on many weeds. In the moister or parkland regions of the prairies and in the coastal areas of British Columbia fall rye is being used to some extent for wild oat control. Other cereal grains have not shown the same competitive ability as fall rye.

(b) In the park belt, or black soil areas, cropping systems which involve seeding down part of the farm to grass-legume mixtures are an aid in the control of weeds, particularly wild oats and Canada thistle. To be effective the forage crops must be left down for at least two years. Local recommendations as to the best adapted crops and cropping systems for a given area should be followed.

6. Community Effort

The individual can clean up his farm, but unless his neighbors do also, he will be faced with new weed infestations. The seeding of grass on properly graded and backsloped roadsides is strongly recommended. Unless sown to grass and annually mowed or sprayed with herbicides, roadsides will continue to grow up to weeds and brush.

Control Measures for Special Annuals

1. Wild Oats

Shallow cultivation is essential. If wild oat seeds are buried deeply in the soil before a thorough drying, they may lie dormant for many years then dry out and germinate if brought to the soil surface by tillage. Therefore, care must be taken to avoid bringing up a fresh supply of seed by deep tillage. The major germination of wild oat seeds occurs in the spring. Hence it is often possible to grow out a crop of wild oats by spring cultivation and delayed seeding. The effectiveness of the summerfallow operations is often lost by seeding too early the following spring. The following is a summary of the tillage methods for wild oat control:

(a) Shallow tillage of stubble in the fall.

(b) Early, shallow spring tillage, i.e. both on summerfallow and on stubble to provide the aeration necessary for wild oat germination.

(c) A second spring cultivation and delayed seeding to an early maturing grain crop.

Green Foxtail

This weed is on the increase in the three Prairie Provinces, especially on the lighter soils of the Dark Brown Soil Zone. The seeds of green foxtail usually germinate the year following their maturity. In any one year the major germination of seeds takes place during the period of May 1 to July 15. Hence very early spring tillage is not a recommended control measure. Careful summerfallowing is necessary to control heavy infestations. Disc-type implements generally result in more satisfactory kills than blade or sweep type cultivators.

Emergency control measures may sometimes have to be employed. In such cases spring ploughing before seeding a grain crop on stubble has proven effective. On heavily infested fallow, spring tillage and deferred seeding to a grain crop until June 15, has resulted in fair control, especially if the crop was cut early for green feed. Green foxtail is a heavy seed producer, therefore seed setting should be prevented either by mowing or by tillage, except in flax where TCA may be used for its control.

General Recommendations for the Control of Perennial Weeds

Perennial weeds such as Canada thistle, perennial sow thistle, and couch grass may be eradicated in one season by repeated or intensive tillage. In a programme of intensive tillage the operations should be made as often as necessary to prevent the appearance of green regrowth for a period of not more than six days. If these weeds occur in patches, the patches should be cultivated separately, and care taken not to scatter root pieces to other areas with machinery.

The use of grass in the rotation will also assist in eradication. Unless infestations around slough edges, stack bottoms, fences, etc., are sprayed or mowed each year, they will continue to start new patches by seed. Non-cultivated land should be sown to grass to prevent reinfestation of other areas.

Control Measures for Specific Perennials

1. Couch grass

Start summerfallowing as soon after harvest as possible. Disc implements are recommended because they do a better job of cutting the sod and will not drag the roots to uninfested areas.

Intensive tillage as previously defined should be carried on throughout the following season. If the infested area is large and subject to erosion, strip cropping of the field is advisable.

General Recommendations for the Control of Persistent Perennial Weeds

Toadflax, leafy spurge, hoary cress, field bindweed, Russian knapweed, and bladder campion are classed as persistent perennials, having roots which can withstand more than one year of intensive summerfallow work. A system of alternating intensive tillage of summerfallow with grain cropping has tended to greatly reduce the stands of these weeds and has given profitable returns.

The seeding of infested areas to a suitable grass which is mowed or sprayed will assist in the control and prevent the spread of these weeds. Intensive tillage to reduce the stand of these weeds prior to seeding the grass will usually enhance the effectiveness of this method of control.

Control of Perennial Weeds by a Combined Programme of Tillage and Herbicides

1. Perennial Sow Thistle and Canada Thistle

In the fallow year normal tillage operations should be carried out until mid-June. The patches of Canada thistle or perennial sow thistle should then be left undisturbed until they reach the budding stage, about mid-July. Treat the infested area with an ester of 2,4-D at 12 to 16 ounces of acid per acre and leave undisturbed for 4 to 6 weeks. Intensive tillage as previously recommended for these weeds should then be carried on until freeze-up.

2. Field Bindweed

In southern Manitoba, where this weed is met with, it is recommended that the tillage of summerfallow cease in mid-July, and the infested areas of the field be treated with 2,4-D ester in mid-August at 12 ounces of acid equivalent per acre.

REGISTERED DELEGATES

Aanestad, A.M.	DuPont Co., Fargo, N.D.
Abeln,B.A.	Dept. of Agr., Minneapolis, Minn.
Abrahamson, Paul	Internation Elev. Co., Minneapolis, Minn.
Adamson, R.M.	Dom. Exp. Sta. Saanichton, V.I., B.C.
Alderson, A.D.	Soo Line, R.R., Room 1816 Soo Line Bldg., Minneapolis, Minn.
Alban, E.K.	Ohio Stage Univ., Dept. of Horticulture, Columbus 10, Ohio.
Alexander, Harold	Geigy Co. Inc., Lincoln, Nebraska.
Allen, Wm. W.	American Chemical Paint Co., Ambler, Pa.
Ampthor, Francis	Rohm and Haas Co., Philadelphia, Pa.
Anderson, E.T.	University of Manitoba, Plant Science Division, Winnipeg, Man.
Anderson, Carl J.	Silas Mason Co., Iowa Ordnance Plant, Burlington, Iowa.
Anderson, E.G.	Division of Botany, Science Service Bldg., Ottawa, Canada
Andreae, W.A.	Dept. of Agriculture, Science Service Lab., London, Ont.
Angerman, John	Minn. Dept. of Agr., McIntosh, Minn.
Ash, Carl G.	Agric. Extension, Crookston, Minn.
Ash, Robert	St. Vincent, Minn.
Ash, W.S.	Farmer, St. Vincent, Minn.
Antogninl, Joe	Geigy Co. Inc., Bayonne, New Jersey.
Affeldt, Leland A.	East Polk County, Fosston, Minn.
Arthur, H.D.	Rosetown Airways, Rosetown, Sask.
Bakke, A.L.	Iowa State College, Ames, Iowa.
Barber, C.L.	Monsanto Chemical Co., St. Louis, Mo.
Barrett, W.L.	Consumers Co-operative Assn., 318 E. 10th St., Kansas City
Barrons, K.C.	Dow Chemical Co., Midland, Michigan.
Barton, Myron H.	John Deere Co., Moline, Ill.
Bauer, J.O.	Chemical Machines Ltd., 630 Lorette Avenue, Winnipeg, Man.
Beadles, Fred	Midway Dist. Inc., Huron, S.D.
Beatty, Robert H.	A.C.P. Co., Ambler, Pa.
Beck, T.V.	Sask. Dept. of Agriculture, Regina, Sask.
Benson, F.W.	Sask. Co-operatives Ltd., Saskatoon, Sask.
Berggren, F.H.	Oldbury Chemical Co., 19 Rector Street, New York, N.Y.
Bergh, Arlo	St. Vincent, Minn.
Bernath, Jim	Hallock, Minn.
Bibbey, R.O.	Ontario Agric. College, Dept. of Botany, Guelph, Ont.
Birt, Fred C.	Chipman Chemicals Ltd., Winnipeg, Man.
Bjerken, Sig.	Div. of Plant Industry, State Dept. of Agric., St. Paul, Minn.
Black, Donald T.	U.S.D. A., EPISAE, Box 107, Station E., Toledo 9, Ohio.
Blain, L.H.	Man. Co-operative Wholesale Ltd., Winnipeg, Man.
Bogle, J.B.	The R.H. Bogle Co., Alexandria, Virginia.
Bohmont, Dale W.	Univ. of Wyoming, Laramie, Wyoming.
Bohner, Ray E.	Weed Supervisor, Sioux Falls, S.D.
Boss, K.A.	Mutual Dealers Whlse. Inc., 2361 Hampden, St. Paul 4, Minn.
Bourns,J.J.	940 Palmerston Avenue, Winnipeg, Man.
Bowman, C.C.	Shawnee Co. Weed Control, Topeka, Kansas.
Bowren, Ken	Exp. Station, Melfort, Sask.
Bragg, K.K.	Department of Agriculture, Division of Botany, Ottawa, Canada.
Brandriet, Matthew	Codington Co., Watertown, S.,Dakota.
Brandt, Albert S.	Co. Commissioner, Roseau Co., Roseau, Minn.
Branson, Harold A.	Standard Oil Co., Sioux Falls, S.D.
Breakey, W.J.	Dom. Exp. Station, Morden, Man.
Bredlie, E.L.	Eldred, Minn.
Brett, W.H.	Brett-Young Ltd., Winnipeg, Man.
Briggs, Geo. M.	University of Wisconsin, Madison, Wis.
Britton, J.W.	Dow Chemical Co., Midland, Mich.
Brookins, W.W.	Flax Institute, 700 Baker Bldg., Minneapolis, Minn.
Brooks, John	Spraying Systems Co., 417 St. Peter Street, Montreal, Que.
Brown, D.A.	Dom. Exp. Farm, Brandon, Man.
Brown, G.R.	Miller Chemical Co., 525 North 15th, Omaha, Nebraska.
Brown, J.	United Grain Growers Ltd., Winnipeg, Man.
Brunn, L.K.	Atlas Powder Co., Wilmington, Delaware.
Brunton, J.G.	Kolker Chemical Works Inc., Newark, N.J.
Bryant, Clyde A.	Dow Chemical Co., Midland, Michigan.
Bryant, David E.	Wallaces Farmer & Ia. Homestead, Des Moines, Iowa.
Bryngelson, E.R.	Rosetown Airways, Rosetown, Sask.
Buchholtz, K.P.	University of Wisconsin, Madison, Wisc.
Buckingham, E.H.	Alta. Dept. of Agriculture, Vermilion, Alta.
Budd, Arch'd. C.	Dom. Exp. Stn., Swift Current, Sask.
Burger, Myron, W.	S.D. Weed Board, Rapid City, S.D.
Burke, John H.	Aerial Applicators Assn., Oklahoma City, Okla.
Burris, T.Fred	C. & O. Ryle, General Motors Bldg., Detroit, Mich.
Burrows, Vernon D.	University of Man. Plant Science Dept., Winnipeg, Man.
Buskirk, G.C.	Pacific Coast Borax Co., Minneapolis, Minn.
Byrnes, J.L.	Sedgwick Co., Weed Dept., Wichita, Kansas.
Byrnes, R.F.	Rohm & Haas Co., 222 Washington Sq., Philadelphia, Pa.
Byers, W.R.	Sherwood Brass Works, Detroit, Mich.
Burtwell, F.G.	The Oliver Corporation, Regina, Sask.

Calvin, Frank N.	Farmers Union Central Exchange, St. Paul, Minn., Box G.
Camery, Morgan P.	Green Giant Co. Le Sueur, Minn.
Campbell, L.C.	Campbell Manufacturing Co., Walthill, Nebr.
Carew, Dean F.S.	Electric Reduction Sales, 137 Wellington St., W., Toronto, Ont.
Carlson, Arne E.	Du Pont, Du Pont Bldg., Wilmington, Delaware
Carnes, A.H.	Pittsburgh Agric., Chem. New York, N.Y.
Carroll, John J.	Riverdale Chemical Co., Harvey, Ill.
Carter, A.H.	Green Cross, 2875 Center Street, Montreal,Que.
Carter, Lorne H.	Manitoba Pool Elevators, 64 Garland St., Portage La Prairie, Man.
Carder, A.C.	Dom. Exp. Sta., Beaverlodge, Alta.
Catherwood, James J.	J.C. Robinson Seed Co., Waterloo, Nebr.
Chamberlin, Joseph C.	U.S.D.A. Forest Grove, Oregon.
Chapin, H.R.	Roseau, Minn.
Cheshire, C.A.	Alta. Dept. of Agriculture, Edmonton, Alta.
Chester, H.	Exp. Station, Lethbridge, Alta.
Chittenden, Dudley B.	Dow Chemical Co., Ames, Iowa.
Chubb, W.O.	Dom. Pilot Flax Mill, Portage La Prairie, Man.
Clarke, M.F.	Exp. Farm, Agassiz, B.C.
Coleman, Ross W.	Dom. Dept. of Agriculture, 730 Dominion Public Bldg., Winnipeg, Man.
Cook, Donald I.	Canada Packers, Winnipeg, Man.
Cook, Ernest, E.	Hypro Eng. Inc., 404 N.Washington, Minneapolis, Minn.
Cookson, J.W.	National Grain, Melville, Sask.
Copeland, G.A.	T. & T. Seeds & Chemicals, Winnipeg, Man.
Corl, Cady, S.	Hanson Chemical Equip., Co. Beloit, Wisc.
Coulter, L.L.	Dow Chemical Co., South Haven , Mich.
Coupland, Robert T.	University of Saskatchewan, Saskatoon, Sask.
Cowling, John	Natura Products Corp., 738 Marin Avenue, Montreal, Que.
Craig, H.A.	Dept. of Agriculture, Legislative Building, Winnipeg, Man.
Crain, Hubert D.	Dow Chemical Co., 615 Olive Street, St. Louis, Mo.
Cramp, G.A.	Inland Steel & Forgings Ltd., 675 Washington Ave., Winnipeg, Man.
Cranston, C.C.	Dept. of Agriculture, Legislative Building, Winnipeg, Man.
Crim, Ralph F.	University Farm, University of Minnesota, St. Paul, Minn.
Crisfield, E.M.	Conrich Service Bd., 617-7 Ave., W., Calgary, Alta.
Crouch, W.E.	Skelly Oil Co., Kansas City, Mo.
Coffman, Clifford	Shady Spring Fruit Farm, Carroll, Ohio.
Conway, J.J.	John Wood Co., Winnipeg, Man.
Coffey, Walker	American Tel & Tel Co., 324 E. 11th St., Kansas City, Mo.
Colvin, Fred	Western Mercantile Co., 1600 Liberty, Kansas City, Mo.
Dales, H.B.	National Grain Co., Saskatoon, Sask.
Daman, W.	Wpg. Gardeners Co-op. Ltd., Ross & Ellen St., Winnipeg, Man.
Davidson, Howard	Chemical Machines, 630 Lorette Ave., Winnipeg, Man.
Dawley, W.K.	Experimental Farm, Brandon, Man.
Derscheid, Lyle A.	S. Dakota State College, Brookings, S.D.
Dickinson, F.L.	United Grain Growers, Hamilton Bldg., Winnipeg, Man.
Dickison, Wm.	H.D. Hudson, Mfg. Co., 589 Illinois St., Chicago, Ill.
Digney, Del	Oberdorfer Foundries, Syracuse, N.Y.
Dreessen, Jack	Okla. A. & M. College, Stillwater, Okla.
Duncan, J.A.	Cockshutt Farm Equipment, Winnipeg, Man.
Dunham,R.S.	University Farm, St. Paul, Minn.
Durbrow, R.J.	Green Bay Flour & Feed, Green Bay, Wisc.
Dutton, W.C.	Dow Chemical Co., Midland, Mich.
Drayson, E.H.	Langford Municipality, Neepawa, Man.
Earley, Edw. C.	Dow Chemical Co., 135 LaSalle, Chicago, Ill.
Edwards, W.H.	Accessories Mfg. Co., Kansas City, Mo.
Edwards, W.L.	Roseau & Lake of the Woods, Roseau, Minn.
Eichler, Wm. A.	Velsicol Corp., 330 E. Grand Ave., Chicago, Ill.
Elder, C.K.	Delavan Mfg. Co., Des Moines, Iowa.
Ellett, Walter	M.D., Morinville, Alta.
Elwell, Harry M.	U.S.D.A., Research, P.O., Box 465, Guthrie, Okla.
Erickson, Andy W.	Roseau County, Roseau, Minn.
Euting, Neil A.	Farmwell, P.O., Box 154, Okauchee, Wisc.
Evans, Frank	Naugatuck Chemicals, Elmira, Ont.
Evans, Marshall	Green Giant Co. Le Sueur, Minn.
Fairbanks, C.L.	Allied Chemical Services Ltd., Calgary, Alta.
Fairbanks, Frank	Houston County, Hokah, Minn.
Feldman, A.W.	U.S. Rubber Co., Bethany, Conn.
Fellman, John A.	3140 S. Federal St., Chicago, Ill.
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Whornham, George	American Chemical Paint Co., Idaho Falls, Idaho.
Whelan, L.	St. Thomas, N.D.
White, H.A.	Bottineau, N.D.
Wichterman, B.M.	Plummer Air Service, Plummer, Minn.
Widdifield, R.B.	Extension Agronomist, Fargo, N.D.
Wightman, D.B.	Midway Distributors, Huron, S.D.
Wilson, L.R.	Extension Service, Brookings,S.D.
Wilson, M.P.	Harrisons & Crosfield, Winnipeg, Man.
Wintan, Crawford	State Dept. of Agriculture, State Capitol Bldg., Oklahoma City, Okla.
Willard, C.J.	Ohio State University, Columbus, Ohio.
Williams, Dave	Agsco Chemicals, Grand Forks, N.D.
Williams, H.F.	University of Missouri, Columbia, Mo.
Williams, Robert	McLaughlin Gormley King, Minneapolis, Minn.
Wirth, J.F.	Hypro Engineering Inc., Minneapolis, Minn.
Witman, E.D.	Columbia-Southern Chem Corp., Pittsburgh, Pa.
Woestemeyer, V.W.	Kansas Bd. of Agriculture, State House, Topeka, Kansas.
Wolcott, Art	Billings, Montana.
Wormley, G.W.	Farm Journal, Washington Square, Philadelphia, Pa.
Wort, D.J.	University of British Columbia, Vancouver, B.C.
Wood, H.E.	Man. Dept. of Agriculture, Legislative Bldg., Winnipeg, Man.
Yahnke, B.L.	Green Giant Co., LeSueur, Minn.
Yingling, Dean E.	Shawnee County, Topeka, Kansas.

Young, D.W.	Iowa State College, Ames, Iowa.
Younggren, C.A.	Kennedy, Minn.
Younggren, Russell	Hallock, Minn.
Zalik, Saul	University of Alberta, Edmonton, Alta.
Zahnley, Dr. W.W.	Kansas State College, Manhattan, Kansas.
Zilke, Sam	University of Saskatchewan, Saskatoon.
Zinter, Clinton	F.H. Peavey & Co., Grain Exchange, Minneapolis, Minn.
Zuhl, Herbert	Dow Chemical Co., Minneapolis, Minn.

LIST OF MEMBER COMMERCIAL ORGANIZATIONS

Accessories Mfg. Co., Kansas, Mo.
Aerial Applicators Association, Oklahoma City, Oklahoma.
Agsoc Chemicals, Inc., Grand Forks, North Dakota.
Allied Chemical & Dye Corp., New York, New York.
American Chemical Paint Co., Ambler, Pa.
Associated Producers, Inc., St. Paul, Minnesota.
Barber W.H. Co., Minneapolis, Minnesota.
Beet Sugar Development Foundation, Ft. Collins, Colorado.
Breyhill Co., Dakota City, Nebraska.
California Packing Corp., Rochelle, Illinois.
California Spray Chemical Corp., Kansas City, Missouri.
Carbide & Carbon Chemical Co., New York, New York.
Chipman Chemicals Limited, Winnipeg, Man.
Clark Mfg. Co., Independence, Mo.
Columbia-Southern Chemical Corp., Pittsburgh, Pennsylvania.
Davey Tree Expert Co., Kent, Ohio.
Dearborn Motors, Birmingham, Michigan.
Deere & Co., Moline, Illinois.
Delavan Mfg. Co., Des Moines, Iowa.
Dow Chemical Co., Midland, Michigan.
Duront, E.I., De Nemours Co.,Wilmington, Delaware.
Evans Orchard Supply Co., Kansas City, Missouri.
Fargo Foundry Co., Fargo, North Dakota.
Farmers Union Central Exchange, St. Paul, Minnesota.
Fertilizer Chemical Supply, Hartington, Nebraska.
Food Machinery & Chemical Corp., John Bean Division, Lansing, Michigan.
Funk, Edward J. & Sons, Kentland, Indiana.
Geigy Company, Inc., Burlington, Iowa.
Goodrich, B.F., Chemical Company, Cleveland, Ohio.
Green Cross Products, Winnipeg, Canada.
Green Giant Co., Le Sueur, Minnesota.
Gre-Sen Manufacturing Co., Minneapolis, Minnesota.
Hahn Co., Evansville, Indiana.
Hanson Chemical & Equipment Co., Beloit, Wisconsin.
Hudson, H.D., Mfg. Co., Chicago, Illinois.
Hunt Orchard Supply Co., St. Joseph, Missouri.
Hypro Engineering Inc., Minneapolis, Minnesota.
International Elevator Co., Devils Lake, North Dakota.
John Blue Co., Inc., Huntsville, Alabama.
John Powell & Co., New York, New York.
Kolker Chemical Works, Inc., Newark, New Jersey.
Kromer O.W., Co., Minneapolis, Minn.
McConnon & Co., Winona, Minnesota.
Mathieson Chemical Corp., Baltimore, Maryland.
Michigan Chemical Corp., St. Louis, Michigan.
Miller Chemical Co., Omaha, Nebraska.
Monsanto Chemical Co., St. Louis, Missouri.
Mutual Dealers Wholesale, Inc., St. Paul, Minnesota.
National Aluminate Corp., Chicago, Ill.
National Grain Co., Limited,Winnipeg, Canada.
Obererfer Foundaries, Incorporated, Syracuse, New York.
Oldbury Electro Chemical Co., New York, New York.
Pacific Coast Borax Company, Los Angeles, California.
Peavey, F.H., & Company, Minneapolis, Minnesota.
Pittsburgh Coke & Chemical Co., Pittsburgh, Pa.
Riverdale Chemical Co., Harvey, Illinois.
Robinson Seed Co., The J.C. Elkhorn, Nebraska.
Rohm & Haas Co., Philadelphia, Pennsylvania.
Sexauer and Son, Geo. P., Brookings, South Dakota.
Sharples Chemicals, Inc., Wyandotte, Michigan.
Sherwin-William Co., Montreal, Canada.
Skelly Oil Co., Kansas City, Missouri.
Spraying & Dusting Association, Chicago, Illinois.
Sprayings Systems Co., Bellwood, Illinois.
Standard Oil of Indiana, Chicago, Illinois.
Swift & Company, Chicago, Illinois.
Thompson Chemical Corp., St. Louis, Missouri.
Thompson-Hayward Chemical Co., Kansas City, Missouri.

LIST OF EXHIBITORS

Accessories Manufacturing Co., Kansas City, Missouri.

Allied Chemical Services Ltd., Calgary, Canada.

American Chemical Paint Co., Ambler, Pa.

Associated Dealers Supply, Willmar, Minn.

Chipman Chemicals Co., Bound Brook, N.J.

Chipman Chemicals Co., Winnipeg, Canada.

Dow Chemical Co., Midland, Mich.

Farmwell Welded Produce Co., Ixonia, Wis.

Geigy Company Inc., Burlington, Iowa.

Golden Arrow Service Ltd., Calgary, Canada.

Green Cross Products, Winnipeg, Canada.

Hanson Chemical and Equipment Co., Beloit, Wis.

H.D. Hudson Manufacturing Co., Chicago, Ill.

Hydraulic Engineering Co., Winnipeg, Canada.

Hypro Engineering, Inc., Minneapolis, Minn.

John Bean Co., Lansing, Mich.

Pacific Coast Borax Co., Los Angeles, Calif.

Pittsburgh Agricultural Chemical Co., New York, N.Y.

Reasor-Hill Corp., Jacksonville, Arkansas.

Riverdale Chemical Co., Harvey, Ill.

Rohm & Haas Co., Philadelphia, Pa.

Spraying Systems Co., (John Brooks & Co.) Montreal, Canada.

Thompson-Hayward Chemical Co., Minneapolis, Minn.